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MELVILLE T. COOK, Editor.

Notes on Insect Conditions in Puerto Rico for the Fiscal Year, July 1931 Thru June 1932
Mortimer D. Leonard

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Concerning the Origin of the White Quartz Sands of Northen Puerto Rico
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NOTES ON INSECT CONDITIONS IN PUERTO RICO FOR THE FISCAL YEAR, JULY 1931 THRU JUNE 1932

By MORTIMER B. LEONARD
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This constitutes the third annual report by the writer on insect conditions in Puerto Rico. The first, for the fiscal year of 1929–1930, was published as part of the Report of the Division of Entomology in the Rept. Ins. Exp. Sta. P. R. for 1929–30, pp. 110–123, 1931. The second appeared in the Jour. Dept. Agr. P. R. 16(2) : 121–144, 1932. These two, together with the present paper, constitute Insect Pest Survey reports for the three years covered by them. During this time the writer was acting as an official Collaborator of the Insect Pest Survey of the United States Bureau of Entomology.

Altho this third and last report by the writer includes notes on the occurrence and status of more insects on more food plants than the others, it still does not pretend to present anything like a complete picture of the activities or occurrence of even all of the more important injurious insects of the leading economic plants of the Island. Desirable as such a record would be, especially if followed out from year to year, it is impossible of accomplishment without the expenditure of much more time and money for travel and a greater number of competent observers than we have so far been able to obtain.

The accumulating, recording and arranging of even so comparatively few observations has necessitated the active help of a number of specialists. Most of the determinations or verifications of species unknown or doubtful to the writer have been made by the several well-known taxonomists at the U. S. Bureau of Entomology. In most cases this is indicated along with the individual records, as are also the names of certain other specialists not officially connected with the Bureau. The writer is indebted to Mr. Richard Faxon and his associates Messrs. Mills, Anderson, Harley and Oakley of the San Juan office of the Federal Plant Quarantine and Control Administration. All of these have obtained many records thru their official observations. The identifications of this material are by the special-

ists in Washington. The names of collectors or observers are indicated for the most part by their initials as follows:

C.G.A. = Anderson	R.G.O. = Oakley
R.F. = Faxon	A.S.M. = Mills
A.G.H. = Harley	F.S. = Seín, Jr.
M.D.L. = Leonard	G.N.W. = Wolcott

Dr. W. T. M. Forbes of Cornell University has assisted in completing the notes on some of the Lepidoptera heretofore little known as far as published records were concerned. Prof. C. R. Crosby also of Cornell, has given much appreciated help in facilitating the preparation of the manuscript for publication.

Alfalfa

Dichomeris piperatus Wlsm., an alfalfa leaf-tyer, was destructively abundant during July at Isabela, rendering the alfalfa unfit for feeding in one patch (G.N.W.). In August the leaf-tyer was found to be rather badly infesting a small experimental patch at Maleza in the municipality of Aguadilla; this is in a rather isolated section containing many hat palms and little farming has been done there; the occurrence of the insect here in injurious numbers at some considerable distance from the only other nearest alfalfa grown at the Isabela Sub-station again raises the question as to what the natural leguminous food-plant really is (G.N.W.).

Prodenia ornithogalli Guen., the velvety cutworm, was abundant during July at Isabela attacking a wide variety of hosts including alfalfa, crotalaria and tomatoes, besides numerous weeds (G.N.W.).

Thermesia gemmatilis Hüb., the velvet bean caterpillar, was abundant on the leaves of alfalfa and sword beans at Isabela during July (G.N.W.).

Reuteroscops uvidus Dist., A Mirid bug (H. G. Barber det.) was reported as infesting in small numbers the leaves and flowers of alfalfa at the Demonstration Farm at Arecibo on June 7 (C.G.A.). It was also collected by sweeping weeds at Santurce, June 29 (C.G.A., H.G.Barber det.).

Algarrobo (*Hymenaea Courbaril* L.)

Myelois decolor Zell. (Pyralidae, C.Heinrich det.). 4 larvae found in 1 out of 6 pods examined at the Demonstration Farm at Arecibo on Mar. 8 (C.G.A.). Not in Wolcott's "List."

Stephanoderes buscki Hopk. (Scolytidae, M.W.Blackman det.) heavily infesting 6 pods examined at the Demonstration Farm at Arecibo on Mar. 8 (C.G.A.). Not in Wolcott's "List."

Annona Spp.

Saissetia hemispherica Targ. (Morrison det.) lightly infesting the leaves of a corazón tree (*A. reticulata*) at Corozál, Feb. 9 (C.G.A.).

Bephrata cubensis Ashm., a Eurytomid, (Muesebeck det.) infesting 1 out of 4 fruits examined at Villalba, Oct. 27 (C.G.A.).

Pseudococcus nipae Mask. (Morrison det.) lightly infesting the foliage of a tree at Corozál, Feb. 9 (C.G.A.).

Pseudoaonidia articulatus Morg. (Morrison det.) 3 out of 14 fruits infested at Ponce, Jan. 8 (R.G.O.).

Empoasca n. sp. related to *minuenda* Ball (P.W.Oman det.) breeding in moderate numbers thruout the year on the foliage of 4 trees of *A. diversifolia* at the Station grounds at Río Piedras (M.D.L.).

Patara albidula Westw. (Fulgoridae, P.W.Oman det.). A few adults on the leaves of the above trees, May 20 (A.S.M.).

?Hyaliodes n. sp., (Miridae, H.H.Knight det.) bred more or less continuously thruout the year on the foliage of the 4 *Anona diversifolia* trees at the Station; both adults and nymphs in all stages could always be found in small to moderate numbers upon examination of the leaves; the nymphs are whitish and somewhat powdery in appearance; the eggs are undoubtedly inserted in the leaf petiole or in the mid-rib but a search was not made to determine this point. The insect was also noticed thruout the previous year which was the first time it had been reported from Puerto Rico.

Avocado

Pseudococcus nipae Mask. (Morrison det.) so badly infested the leaves and twigs of a small tree at Mayagüez on Dec. 12 that it was practically dead (A.G.H.).

Empoasca minuenda Ball (P.W.Oman det.) A moderate number of adults and nymphs found feeding on the leaves of a tree at Santurce on Mar. 1 (A.S.M.).

Banana

Cosmopolites sordidus Germ., the banana root-weevil, has apparently been about as injurious as during the past year. It of course also affects plantains to which it often seems to do somewhat more damage than to bananas.

Telephanus pallidulus Chevr., a Cucujid, (W.S.Fisher det.). 1 adult was found in a decayed flower-stalk at Bayamón, May 15 (C.G.A.).

Bothriocera venosa Fowl., (P.W.Oman det.) a Fulgorid; small number of adults found on the leaves of 5 plants at Bayamón, Apr. 8 (C.G.A.).

Homophysa dolotalis Möschler (W. Schaus det.). A small number of adults of this Pyralid on the 5 plants mentioned above. It was also taken at light in Bayamón, May 15 (Schaus det., C.G.A.). Apparently previously recorded only from the type material, but Dr. Forbes found the species common and apparently general in 1930.

Bean (Lima & String)

Tetranychus sp., a mite (H.E.Ewing det.), was found infesting the leaves in most lima bean fields at Loíza examined during January; a few of the leaves had turned yellowish but the damage was only slight (A.S.Mills).

?Hyaliodes n. sp. a Mirid (H.H.Knight det.) generally distributed during the end of August in moderate numbers on the underside of the leaves of a small patch of pole limas at the Station in Río Piedras; no nymphs were present; adults also on a small adjoining patch of okra. Both plants were only 25–30 yards away from 4 *Anona diversifolia* trees on which the bugs were breeding.

Agromyza inaequalis Mall. a bean leaf-miner (C.T.Greene det.) infesting with blotch mines practically all the leaves in a small garden patch of limes in Río Piedras, Jan. 15 (R.F.). Blotch mines in bean leaves have been observed in various places thruout the year in moderate numbers and it is presumed that they are made by this species.

Aphis rumicis L. in considerable numbers on a small patch of pole limas at the Station at Río Piedras early in Sept. (M.D.L.) and lightly infesting a 2-acre patch of limas at Loíza, Nov. 6 (A.S.M.; P.W.Mason det. both records).

Megoura viciae Kalt., an aphid (P.W.Mason det.) lightly infested lima bean pods near Río Piedras Feb. 26 (R.F.). Apparently not previously reported from P. R.

Myzus probably n. sp., an aphid (P.W.Mason det.) moderately infesting a patch of string beans at Adjuntas, Mar. 21 (R.G.O.).

Pseudococcus virgatus Ckll. (Morrison det.) lightly but generally infesting a small patch of pole limas at the Station at Río Piedras Sept. 8 (M.D.L.) and lightly infesting the pods of limas at Loíza, Mar. 14 (A.S.M.).

Agallia albidula Uhler, a leafhopper (P.W.Oman det.) lightly infested the leaves of lima beans, cassava melon and tomatoes at Loíza, Nov. 6 (A.S.M.).

Thyantor perditor Fab., a Pentatomid (H.G. Barber det.). Adults in moderate numbers on the leaves of a 3–acre lima bean patch at Loíza, Feb. 7 (A.S.M.).

Lachnopus curvipes Fab., (L.L.Buchanan det.). Several adults of this weevil found resting on plants in a 1-acre patch of limas at Vega Baja, Nov. 24 (A.S.M.).

Laphygma frugiperda A&S. (W. Schaus det.) lightly infested the pods in a 1-acre patch of limas at the Substation at Isabela, Jan. 12 (C.G.A.).

Phytometra oo Cramer, a Noctuid (W. Schaus det.), lightly infested a small garden patch of limas at Río Piedras, Jan. 15 (C.G.A.).

Nezara viridula L. (H.G.Barber det.) moderately infesting the leaves and pods in an acre of limas at Río Piedras, Dec. 12 (A.S.M.); *Nezara viridula* L. occurred in small numbers of adults on the leaves of a 3-acre patch of lima beans at Loíza, Feb. 7 (A.S.M., H.G.Barber det.).

Ellipes minuta Scudder, a Gryllid, (A.N.Caudell det.) found on a lima bean leaf in a small patch at Vega Baja, Nov. 24 (A.S.M.).

Cycloneda limbifer Csy. (E.A.Chapin det.) on a leaf in a small patch of limas at Río Piedras, Jan. 16 (A.S.M.).

Carpolonchaea pendula Bezzi (Sapromyzidae, Aldrich det.). A few larvae, from which adults were reared, in the pods in a hamper of limas at Isabela, Mar. 24 (C.G.A.). Apparently new to P. R.

Callosobruchus chinensis L. (H.S.Barber det.) found in small numbers in lima beans grown in Ponce, and kept in the office, May 25 (R.G.O.). See also under "Miscellaneous."

Corythucha gossypii Fab. was apparently generally distributed and more or less injurious to lima and string beans as usual thruout the year.

Empoasca fabalis DeL., the common bean leafhopper was generally distributed and present in its usual numbers thruout the year, often doing much damage to plantings during the drier periods, especially where they were unsprayed.

Lamprosema indicata Fab, the bean leaf-webber, was undoubtedly more or less injurious wherever beans were grown; it moderately infested pole limas at the Station during July and August but seemed to increase somewhat so that it was often doing considerably injury to all lima bean fields examined in Nov., Dec. and Jan. at Río Pie-

dras, as well as at Vega Baja, Loíza and Isabela. The moths were fairly common at light Sept. 25–27 at Puerto Real, Vieques Id. (M.D.L.).

Larvae of a Eulophid, *Grotiosmyia nigricans* How. (Muesebeck det.) found feeding on larvae of *Lamprosoma indicata* F. at Río Piedras on Jan. 15 (C.G.S.). Apparently not before recorded from Puerto Rico.

Goniurus proteus L., the bean leaf-roller, was also general but observations would indicate only light to moderate damage to limas at Río Piedras, Cidra (1 larva out of 100 plants examined by Mills) and Loíza.

Ceratoma ruficornis Oliv., a bean leaf-beetle, was present to some extent in a number of fields examined; it was reported as moderately infesting a 2-acre field of limas at Loíza on Jan. 8 and lightly infesting a 1-acre field at Río Piedras on Jan. 1 (A.S.M.).

Diabrotica graminea Baly, was undoubtedly general thruout the year as has been the case the past few years; it did considerable damage to the blossoms and leaves of pole limas at the Station and was reported as doing considerable damage also to snap beans at Orocovis on Feb. 2 by Mills.

Bean pod-borers. The comparative abundance of the 3 lepidopterous pod-borers most commonly found in lima and string beans was somewhat different than during the previous year. A report prepared by Messrs Faxon and Mills of the P.Q. & C.A. office in San Juan, altho it covers primarily the shipping season for green beans to the States—Nov. 1 to Mar. 31—fairly well summarizes the situation for the period of the whole fiscal year; it is as follows:

"*Fundella cistipennis* was usually present in small numbers in lima beans that were being shipped to the States. In previous seasons *Etiella zinckenella* Treit. appeared to be more prevalent than Fundella, but this season the situation was reversed as Fundella larvae were found to be more frequently in the pods of lima beans than either *Maruca testulalis* Geyer or *Etiella zinckenella.* The infestations of *Fundella cistipennis* were light, the highest being 3 per cent found in a hamper from Isabela. It was found to be present in shipments from Loíza, Vega Baja, Arecibo, Isabela and Adjuntas. Fifteen collections were forwarded to Washington for determination and many more could have been sent from other shipments. *Etiella zinckenella* was found only in 3 shipments of lima beans and 4 of gandules (pigeon peas)."

"*Maruca testulalis* was difficult to find until January, 1932 and the later infestations in lima and string beans and gandules were

usually light. This was particularly true of gandules as only one interception was made in cull pods at Arecibo, altho hundreds of boxes were shipped to the States. Practically the only serious infestation in lima beans was found at Cidra, Feb. 26, where 11 per cent of the pods in a 3-acre field of bush limas were infested with Maruca larvae. Sixteen collections were sent to Washington for determination from beans grown at Loíza, Río Piedras, Vega Baja, Arecibo, Isabela, Cidra and Cayey."

It is interesting to note that only 1 moth of *Etiella zinckenella* was taken by the writer during three nights of collecting at light at Puerto Real, Vieques Id., Sept. 25–26, year.

An adult of *Microbracon thurberiphagae* Mues. (Muesebeck det.) reared from a larva found on a larva of *Maruca testulalis* Geyer in a hamper of lima bean pods from Vega Baja, Mar. 24 (C.G.A.). Three larvae of this parasite were also found infesting 1 out of 20 larvae of *Maruca testulalis* in lima bean pods at Cidra, Feb. 2 (A.S.M.). The first record for Puerto Rico; Bruner has recently recorded it from Cuba from the same host.

Beet

Disonycha laevigata Jacoby was observed lightly infesting a small patch of beets at Jayuya on June 14 (R.G.O.) but was undoubtedly generally distributed and injurious as usual to beets, swiss chard and related crops. (See also "Micellaneous").

Bidens pilosa radiata

Thrips abdominalis in moderate numbers in the flowers at Río Piedras on May 31 (A.S.M.; J.R.Watson det.).

Protalebra brasiliensis DeL., known to be a minor pest of sugar cane, continued to be abundant thruout this past year as during the previous one on all patches of the weed at El Morro in San Juan. It seemed to be very scarce if at all present at the Station in Río Piedras on the same food-plant.

Books

Rhizopertha dominica Fab. (*R. pusilla* Fab. is a synonym, A.J. Mutchler det.) according to Dr. Wm. A. Hoffman has done considerable damage to the books in the library of the School of Tropical Medicine thruout the year and for a couple of years previous. It is a cosmopolitan Bostrychid beetle injurious to lumber.

Bougainvillia

Orthesia insignis Douglas was reported as badly infesting a large vine at a home in Santurce on Apr. 20 and on Apr. 22 specimens were received from Bayamón with the statement that an unidentified tropical ornamental was rather badly infested.

Cabbage

Plutella maculipennis Curtis, the diamond-back moth, was observed in a number of places and was presumably as common and injurious as formerly.

A slug, *Veronicella occidentalis* Guilding, reported as doing considerable damage to cabbage, but also eating holes in green tomato fruits in a 1-acre garden planting at Trujillo during April.

Corythaica planaris Uhl., the eggplant lace-bug, was found in small numbers, adults, in a planting at Ponce on May 14 (R.G.O., H.G.Barber det.).

Cacara tuberosa (Lam.) Britton

Alysia analis Cress. was found on several plants at Ponce on June 28 (R.G.O., Muesebeck det.).

Canna

Calpodes ethlius Cramer, the canna leaf-roller, became destructively abundant during July on a number of plants at Isabela, averaging 1 or 2 larvae per plant (G.N.W.); it was observed in several other localities also.

Frankliniella insularis Franklin. See under "Rose" for note on damage to canna blooms.

Carrot

Systena basalis Duv. was observed in large numbers on the leaves in a 1/10-acre planting at Jayuya on June 14 (R.G.O., H.S.Barber det.).

Cashew nut (*Anacardium occidentale* L.)

Selenothrips rubrocinctus Giard, the red-banded thrips, defoliated several trees at Río Piedras in September and was again observed infesting the new foliage on the same trees the following February; in April a tree in another place near Río Piedras was badly infested (F.S.).

Cassava

Saissetia oleae Bernard so badly infested several considerable sized plantings from 6 months to 1 year old at the Manicomio near Río Piedras the latter part of July that many of the plants were entirely devoid of leaves and in a dying condition; several branches submitted for identification were badly encrusted with the scales in all stages of growth (S.Molinary).

An unidentified *whitish scale* was also present in the above infestation but apparently not as abundant as the other altho one of the branches brought in was badly infested.

Lonchaea chalybea Weid., the cassava shoot-borer, was received under date of Oct. 2 from the Agricultural Agent at Bayamón who stated that for some little time the insect had been very common in all the plantings in the district and had considerably reduced the yield.

Cryptosephalus tristiculus Weise, a Chrysomelid, (H.S.Barber det.), was found, 1 adult, on a leaf of one plant Apr. 29 (C.G.A.) at Lares.

Aphodius lividus Oliv. was found, 2 adults, on a plant at Santurce on June 29 (C.G.A., H.S.Barber det.).

Red-spiders, *Tetranychus* sp., were more or less injurious as usual, especially during the drier periods.

Cassia siamea

Asterolecanium pustulans Ckll. was observed to be badly infesting several ornamental trees at the Director's home on the Station grounds on May 6 at Río Piedras (F.S.).

Castor Bean

Corythucha gossypii Fab. was more or less abundant on nearly all plants observed in various parts of the Island thruout the year as is usual.

Casuarina equisetifolia Forst

This tree which is widely grown in Puerto Rico as an ornamental and as a wind-break for citrus had heretofore been considered as practically if not entirely immune from insect attack in the Island. Continued obseration has finally disclosed the following insect pests:

Icerya purchasi Mask., the cottony cushion—scale was first found in very small numbers in Santurce in October but during the late winter and spring and early summer it became generally distributed

and often injurious on ornamental casuarina trees and hedges thruout San Juan and Santurce south to at least Martín Peña and also infested wind-breaks in several citrus groves in Palo Seco, Bayamón and Dorado.

Icerya monserratensis R.& H.,another mealy bug which has been long known to infest *Ficus nitida* or West Indian Laurel (which see) in Puerto Rico was brought in on April 10 by Edumudo Martínez of the Insular Forest Service as moderately infesting all the casuarina trees in the Plaza at Cayey. He stated that there had been some rain there recently and that the insects were apparently somewhat less numerous than at a previous inspection about 3 weeks or a month ago.

Howardia biclavis Comstk. (Morrison det.) was found infesting a number of trees at the Scoville place on the Carolina road near Río Piedras (G.N.W.); it was also collected in moderate abundance on several small trees at the Forest Service Station at Río Piedras on Mar. 29 (M.D.L.).

Hemichionaspis minor strachani Cooley (Morrison det.) was also collected from one tree lightly infested at the Forest Service Station on Mar. 29 (M.D.L.).

Diaprepes spengleri L. adults were observed in considerable numbers in copula and aparently feeding to a slight extent on a hedge near San Juan on May 7 (M.D.L.).

Cedro Hembra (*Turpinia paniculata* Vent.)

Hypsiphila grandella Zell., a lepidopterous shoot-borer (Heinrich det.), was reported on June 11 as injuring to a considerable extent about 4,000 trees planted among coffee for shade at Jayuya and on June 29, 1931, 1,000 young trees recently planted in a coffee finca at Adjuntas. In mid-July F. Seín Jr. reported that a number of young trees were moderately infested in the Rural School planting in Lares. This pest was also generally present and badly skeletonizing these shade trees in another large coffee finca (Hacienda Carmelita) in the general vicinity of Adjuntas in September.

Celery

A mealy-bug, presumably *Pseudococcus citri* Risso, was found on July 2 to be moderately infesting several plants (one badly infested) at the Station grounds in Río Piedras. The bugs were clustered at the base of the plants just above the ground and a few were on the roots. There is only one previous record for celery in Puerto Rico —collected by T. H. Jones, July 3, 1912, Río Piedras, Morrison det.

Chalcas exotica

Coccus viridis Green, the green scale, was observed on the leaves and twigs of one bush at Vega Baja on Dec. 29 (R.F.).

Chayote

Margaronia nitidalis Cr. 2 larvae in a crate on Feb. 26 for shipment to the States (C.G.A., Schaus det.).

Chick pea

Rhizopertha dominicana Fab., a Bostrychid beetle, was found infesting about 10 per cent of the peas in a small package in Santurce on Nov. 11 (R.G.O., W.S.Fisher det.).

Cephalonomyia gallicola Ashm., (Muesebeck det.) was lightly infesting a package the same package (R.G.O.). Not in Wolcott's "List".

Chocolate

Oryzaephilus surinamensis L., the saw-toothed grain beetle, was found, several adults, larvae and pupae, in the chocolate coating of candies from Switzerland via New York about a year previous (A. S.M., Fisher & Boving det.).

Laemophlaeus minutus Oliv. (Fisher det.). An adult on chocolate cake in a restaurant in San Juan, June (C.G.A.).

Chrysobalanus icaco L.

Nessorhinus vulpes A. & S. (Membracidae, P.W.Oman det.). A few adults on the stems of hicaco at Arecibo, May 20 (C.G.A.) Not in Wolcott's "List".

Citrus

Icerya purchasi Mask., the cottony cushion-scale, was first discovered in considerable abundance on a number of grapefruit trees in a large grove at Palo Seco on April 2. Continued search from then on to the end of June discovered infestation in grapefruit groves in Bayamón and Dorado, 6 in all, and on many ornamental citrus trees thruout San Juan and Santurce south to at least Martin Peña. In 3 or 4 of these groves the infestation developed rapidly to considerable proportions but it was largely checked by the end of the year by spraying, native natural enemies and the prompt introduction of the Australian or Vedalia ladybeetles. The most efficient and widespread parasite was a Phorid fly, *Syneura cocciphila* Coq.,

which was present in nearly every infestation found on all food-plants, often killing as high as 50 per cent of the insects in large individual colonies. Other natural enemies were the lace-wing fly, *Chrysopa collaris* Schneider, the common Coccinellid, *Cycloneda sanguinea* L. and often where well-established dense colonies were present the scavenger and scale-feeding caterpillar, *Ereuntis minuscula* Wlsm. Food-plants other than citrus were: Australian pine, *Casuarina equisetifolia;* rose; gallego, *Polsias guilfoylei;* gallito, *Agati grandiflora;* pigeon pea; María, *Callophyllum antillanum;* and Acalypha sp.

Asynapta citrinae Felt an Itonid cambium miner found in July in grapefruit twigs at Isabela; the pink maggots formed cocoons in the soil on July 11 and 2 adults emerged on July 15 (G.N.W.).

A snail, as yet undetermined, of small size, skeletonized the leaves in a seed-bed of several thousand grapefruits at the experimental plantings at Trujillo Alto the end of August; the seedlings were not more than 6 ins. high and were generally infested, about 5 per cent being killed before control measures could be applied (E.H. Twight).

A mite, *Uropoda* sp. (H.E.Ewing det.) found infesting the skin of 1 out of 50 grapefruits examined at Mayagüez on Jan. 22 (A.G.H.).

Catyclysta miralis Möschler (Wm. Schaus det.) a Pyralid moth taken on a kumquat leaf at Río Piedras Mar. 15 (A.S.M.).

Lachnopus curvipes Fab., a weevil, was reported by Dr. Wolcott to be locally more abundant around Isabela during July than the common "vaquita", *Diaprepes spengleri,* which causes the bulk of the injury to citrus foliage. A small number of adults were found on grapefruit leaves at Barceloneta on May 10 and a few eating the leaves in a grove at Vega Alta on May 15 (C.G.A.).

Diaprepes spengleri L. and its varieties was about as abundant, with local variations, as usual thruout the citrus section, doing considerable damage to foliage and often causing very young fruits to drop by cutting them off at the stem attachment. In general the season of greatest abundance of adults was apparently April or May into June or July. Dr. Wolcott reported that in September adults were less abundant at Isabela and only 1 or 2 egg-clusters could be found after several hours search on a certain day, whereas many were found toward the end of August in the same place in a much shorter time.

Exopthalmodes roseipes Chev., the "vaquita verde" beetles were present during the spring and early summer as usual doing injury

to citrus foliage; they were observed as especially abundant in May in several grapefruit groves in Palo Seco, Manatí and Vega Alta.

Blossom thrips were common in various parts of the citrus section during a considerable blossoming period from April into May. Specimens were identified by J.R.Watson as *Frankliniella difficilis* Hood and *F. insularis* Fkln. The latter is the common black blossom thrips thruout the West Indes. *F. cubensis* Hood, a yellow species, was also apparently involved. It should be here noted that the writer overlooked in a note on citrus thrips in Puerto Rico (Jour. Econ. Ent. 25(4): 934–935, 1932) that Dozier had listed *F. tritici* Fitch as taken in grapefruit blossoms at Trujillo Alto (Jour. Dept. Agr. P. R. 10(3&4): 280, 1926, issued 1927).

Papilio androgeus Cr., the orange dog, was reared to adult on July 12 from a caterpillar found on grapefruit foliage sometime previous in Isabela; 2 other caterpillars brought in on the 12th (G.N.W.).

Corythucha gossypii Fab. was observed in several places from time to time infesting both grapefruit and lime and citron foliage but more abundant and actively breeding on the last especially at Palo Seco and Río Piedras.

Fecelia minor Voll. (Pentatomidae, H.G.Barber det.) adults found in small numbers on the fruit in an orange grove near Ponce and in two groves near Peñuelas on Jan. 25 and on March 8 (R.G.O.). Adults were very prevalent during January and February in the Ponce district on wild oranges causing about an 8 per cent loss of fruit. Not in Wolcott's "List."

Dialeurodes citrifolii Morg., the cloudy winged whitefly, heavily infesting the leaves of two lime trees at Ponce on April 8 (R.G.O., Morrison det.).

Pseudococcus citri Risso, the citrus mealybug, was observed to be fairly common on the larger branches of grapefruit trees in several groves in the eastern part of the citrus section.

Piezosternum subulatum Thunb. (Pentatomidae, H.G.Barber det.). 1 adult on a grapefruit leaf at Bayamón on June 12 (C.G.A.).

Toxoptera aurantii Boyer was moderate to abundant on new growth during the spring in grapefruit in several sections, being especially noted at Arecibo, Bayamón and Manatí.

Aphis gossypii Glov., the melon aphid, heavily infested the tender shoots and leaves of many young grapefruit trees at Añasco on Jan. 27 (A.G.H., P.W.Mason det.). Apparently the first record of injury to citrus in Puerto Rico.

Aleurothrixus howardi Quaint. (G.B.Merrill det.) was observed in moderate numbers on grapefruit leaves on several trees in a large grove in Palo Seco during April and on one tree in a grove at Toa Baja in May (A.S.M., M.D.L.).

Eugnathodus guajanae DeL. (Cicadellidae, P.W.Oman det.) an adult on a grapefruit leaf at Bayamón, May 15 (C.G.A.).

Dikraneura (*Hyloidea*) *depressa* McAtee (Cicadellidae, P. W. Oman det.) in small numbers, adults, on several grapefruit trees at Arecibo, Apr. 5 (R.F.). Not in Wolcott's "List."

Empoasca minuenda Ball (Cicadellidae, P.W.Oman det.) present in small numbers as adults on grapefruit leaves in a grove at Arecibo on Apr. 5 (C.G.A.). Not in Wolcott's "List."

Ormenis infuscata Stål (Fulgoridae, P.W.Oman det.). Several adults on grapefruit leaves at Arecibo, Apr. 5 (C.G.S.).

Ormenis quadripunctata Fab. (Fulgoridae, P.W.Oman det.) a few adults on grapefruit leaves at Bayamón on Apr. 8 (A.S.M.).

Delphacodes sp. probably new (Fulgoridae, P.W.Oman det.)—an adult on a grapefruit leaf, Bayamón May 15 (C.G.A.).

Ecpantheria icasia Cram. (Arctiidae, Schaus det.)—an adult reared from a larva on a grapefruit leaf, Bayamón, May 15 (C.G.A.).

Edessa cornuta Burm. (Pentatomidae, H.G.Barber det.) in small numbers as adults on grapefruit leaves on several trees at Bayamón on Apr. 15 (C.G.A.).

Rhaptinus torquatus Oliv. (Curculionidae, L.L.Buchanan det.) in small numbers on grapefruit leaves at Las Marías, May 3 (C.G.A.).

Brentus volvulus Fab. (Brentidae, L.L.Buchanan det.) adults found on grapefruit blossoms at Mayagüez, May 17 (A.G.H.).

Chionaspis citri Comstock, was common to abundant on the trunks and larger branches of many grapefruit trees examined during April and May in groves at both Palo Seco and Bayamón; a considerable percentage of the male scales had parasite emergence holes.

Ceroplastes floridensis Comstock, the wax scale, was present in small numbers on a few grapefruit trees in a grove at Palo Seco and was also observed in one or two other places in the eastern part of the citrus section.

Anastrepha sp. the west Indian fruit-fly was found lightly infesting a few grapefruits in one grove near Mayagüez and in two groves near Arecibo in April.

Coconut

Aspidiotus destructor Sign., the coconut scale, was reported by F. Méndez, Coconut Specialist at the Station, as being not nearly so

abundant at Cabo Rojo in September as it had been 5 or 6 months previously. On Sept. 26, as far as could be observed practically every coconut palm on Vieques Island was more or less infested, those towards the eastern and drier end of the Island especially so, many palms having a sickly and yellow appearance and in some cases even the fruits were encrusted with the scales.

Coffee

Leucoptera coffeella Staint., the coffee leaf-miner, was generally distributed and quite abundant thru the whole of the Hacienda Carmelita, a large coffee farm in the vicinity of Jayuya, visited Sept. 9–10 but apparently not much damage was being done to bearing trees. According to Vicente Medina, Coffee Specialist at the Insular Experiment Station, the leafminer was more abundant during Dec. and Jan. than the two previous months due to generally dry weather thruout the coffee growing regions.

Coccus viridis Green, the green scale, was general tho not very abundant thruout the Hacienda Carmelita on the visit referred to above, the younger shoots and leaves being more infested than older parts, as is usual.

Psychonoctua personalis Grote, a Coffee stem-borer was received under date of Sept. 29 in injured branches from the Agr. Agent at Corozal with the statement that considerable damage was being done by the hollowed-out branches being broken off when they were bent down by the pickers.

Apate francisca Fab., a coffee stem-borer, was reported by Vicente Medina of the Station staff as damaging some trees on a farm at Adjuntas on April 18.

Psyllia minuticona Cwfd. present in small numbers as adults on coffee leaves at Adjuntas April 14 (R.G.O., P.W. Oman det.).

Bothriocera venosa Fowl. (Fulgoridae, P.W.Oman det.), in small numbers as adults on coffee leaves at Adjuntas, April 14 (R.G.O.).

Scymnillodes gilvifrons Chpn. (Nitidulidae, E.A.Chapin det.) on coffee leaves at the Torres finca at Adjuntas, April 14 (R.G.O.). Not in Wolcott's "List."

Psorolyma maxillosa Sic. (Coccinellidae, E.A.Chapin det.) in small numbers on the leaves out of 30 plants examined at Utuado on May 17 (R.G.O.).

Corn

Heliothis obsoleta Fab, the corn earworm, infested practically every ear of sweet corn at Isabela during September (G.N.W.); the

ears in 4 boxes of corn from Añasco examined Mar. 7 were heavily infested (A.G.H.).

Diabrotica graminea Baly was abundant and injurious to corn at Isabela during July (G.N.W.).

Disonycha laevigata Jacoby present in large numbers on corn leaf-sheaths at Loíza on April 11 (C.G.A.).

Peregrinus maidis Ashm. adults common on leaf-sheaths of several plants at Loíza Apr. 11 (C.G.A.).

Solubea pugnax Fab., (H.G.Barber det.) in small numbers as adults on corn leaves at Jayuya on May 14 (R.G.O.).

Orius (Triphleps) insidiosus Say (Anthocoridae, H.G.Barber det.) adults common on leaf-sheaths of several plants at Loíza, Apr. 14 (C.G.A.).

Laphygma frugiperda A. & S. moderately infesting corn ears at Loíza, Apr. 11 (C.G.A.).

Oscinella coxendix Fitch. (J.M.Aldrich det.) common on leaf-sheaths of several plants at Loíza, Apr. 11 (C.G.A.). This species is little-known in Puerto Rico.

Cotton

Pectinophora gossypiella Saund., the pink bollworm, was much less injurious to this past year's crop than to that of the previous year; the explanation for this is not clear. The clean-up, altho not carried out as thoroly as had been hoped for on the crop remnants from the previous season, might have been responsible for some reduction in the pink bollworm population. The acreage in cotton was greatly reduced, however, especially in the South Coast and theoretically there should have been a greater infestation. As an example of the reduced infestation it may be stated that as late as Jan. 20 J. Pastor Rodríguez, Cotton Specialist at the Station, reported a 1-acre field in the South Coast, which last year had been very badly infested, to show less than 1 per cent of the bolls infested and a nearby field only about 5 per cent. (For a more complete account of conditions covering the infestation of the previous crop thru picking into the fall of 1931 on the North Coast see Leonard in Jour. Dept. Agr. P. R. 16(1) : 65–73, 1932).

Alabama argillacea Hübner, the cotton leaf-worm, was also much less numerous and injurious than during the previous crop; it was, in fact, practically negligible; two small outbreaks were reported from the South Coast during the latter part of December and the middle of January but these were easily controlled by two applications of poison. During July (on the previous crop) it was destruc-

tive thruout the whole North Coast but most injurious around Isabela and Camuy; during August the attacks naturally abated on the North coast due largely to the fact that most of the plants by that time were old and no longer succulent. According to F.E.Rorke of the San Juan Ginnery at least 80–85 per cent of the crop had been picked by the end of August in the North Coast but the leaf-worm continued active until at least the middle of the month around Manatí and apparently there was a certain amount of leaf-worm feeding in several other localities.

Dysdercus spp., mostly *D. andreae* L, the common cotton stainer, with occasionally undoubtedly a slight intermixture of *D. neglectus* Uhl. were more or less abundant on cotton bolls as usual, especially during the end of the crop, but altho they are responsible for some staining of the lint no attempt has been made to estimate how much damage is done.

Empoasca sp. leafhoppers were always to be found as usual in small to moderate numbers in all stages on the plants. Altho the Puerto Rican specimens have never as yet been specifically determined they probably belong to *E. gossypii* DeL described from Haiti in the April 1932 number of this Journal.

Nepticula gossypii Fbs. & Leon., the cotton leaf-miner, was present apparently in about the same numbers on the South Coast as during the previous year but as before was not observed to occur in the North Coast.

Ephestia cautella Wlk. (Pyralidae, Heinrich det.). A few adults observed on several tons of cotton seed cake at the Ginnery at Hato Rey on Mar. 9 (A.S.M.); an adult was also taken on a sword-bean leaf at Arecibo on Mar. 8 (C.G.A.).

Crotalaria

Utethesia ornatrix L., the rattlebox moth, was reported as very abundant by Dr. Wolcott the middle of Oct., the caterpillars searching for food in great numbers on the beaches at Isabela; the moths were also common at lights at Isabela. This species was more or less injurious as usual to Crotalaria grown for seed thruout the Island.

Nezara viridula L. was present in large numbers, both as nymphs and adults, on the leaves and pods on the Preston farm at Naguabo on June 3 (C.G.A., H.G.Barber det.).

Nezara marginata P. de B. Many specimens clustered on a single pod at Isabela in July (G.N.W.).

Delphacodes teapae Fowl. (Fulgoridae, P.W.Oman det.). A few adults on the leaves at the Preston farm at Naguabo on June 3 (C.G.A.).

Cucumber and Melon

Aphis gosspii Glov. was troublesome to cucumbers at the Station during July necessitating frequent spraying. It also heavily infested a 2–acre planting of cassava melons at Loíza in January (A.S.M., P.W.Mason det.). It was undoubtedly general and injurious as usual.

Diabrotica graminea Baly (H.G.Barber det.) was doing light damage on a 2-acre planting of squash at Vega Alta on Nov. 24 (A.S.M.).

Diabrotica innuba Fab., a leaf-beetle, was quite abundant on cantaloupes at Isabela in July (G.N.W.).

Diaphania hyalinata L., the melon worm, was observed the end of July to be considerably injuring the leaves and blossom-buds of a fair-sized patch of cucumbers at the Station at Río Piedras; the vines were just beginning to run and no fruit had set as yet. It necessitated spraying almost every other day during August. On Jan. 4 it was observed doing considerable damage to young cassava melon vines at Loíza; moderate damage observed on squash vines at Vega Alta in Nov. and to cucumber at Manatí in January; in a well sprayed field of cucumbers, however, at Barceloneta only slight damage was being done (A.S.M.).

Nezara viridula L. lightly infested squash leaves in a 2-acre field at Vega Alta, Nov. 24 (A.S.M.).

Margaronia nitidalis Cr., the pickle worm,—a single larva found in a fruit while examining a crate offered for shipment; the adult was reared (A.S.M., Schaus det.).

Agallia albidula Uhl. (P.W.Oman det.) lightly infested cassava melon at Loíza, Nov. 6 (A.S.M.).

Argyria diplomachalis Dyar (Pyralidae, Wm. Schaus det.) one adult resting on a cucumber leaf at Loíza, Mar. 14 (A.S.M.). Only one previous published record—"on weeds and at light" Río Piedras, 1916.

Dasheen

Atherigona orientalis Schiner (Anthomyidae, Aldrich det.) maggots were found infesting 1 root out of 10 examined in the Public Market in San Juan on Mar. 30 (C.G.A.). Apparently not previously listed from P. R.

Eggplant

Epitrix parvula Fab., the tobacco fleabeetle, heavily infesting 20 plants examined at Loíza on Mar. 14 (A.S.M.; H.S.Barber det.).

Myzus persicae Sulz. moderately infesting 20 plants at Loíza in March but it was injurious in other places also during the year as usual.

Lysiphlebus testaceipes Cress. Adults were numerous on eggplant leaves at Loíza, Mar. 14 where they were undoubtedly parasitizing aphids which were numerous on the plants (C.G.A.) Musebeck det.).

Coyrthaica planaris Uhl. (= *C. monacha* Stal.) was observed moderately infesting the foliage of about 10 out of 40 plants examined at Juncos on Jan. 25 (R.F., H.G.Barber det.). Altho few definite observations were made other than this it was undoubtedly present and more or less injurious as usual.

Aleurotrachelus trachoides Back, badly infesting a number of experimental potted plants in the Station greenhouses during April.

Argyria opposita Zell. (Pyralidae, Schaus det.). 5 moths collected on eggplant leaves at Juncos, Jan. 25 (R.F.). Not in Wolcott's "List."

Kalotermes marginipennis intercepted in a shipment of egg-plants from Puerto Rico (S.R.A., P.Q. & C.A., issued March, 1932, p, 347). Not in Wolcott's "List."

Ficus sp.

Diaprepes spengleri L., adults were present in fair numbers (but less so than on the same trees last June) on several trees of a *Ficus* probably *laevigata* near Santa Isabel on August 20–22, 1931. 35 egg masses were collected with Dr. J. G. Myers during several hours hours careful search in an effort to obtain Trichogrammatid egg-parasites for introduction into Barbados. The percentage of parasitism could not to determined at the time.

Gallego (*Polysias Guilfoylei*)

Icerya purchasi Mask., the cottony-cushion scale, was first found infesting this plant on Feb. 26 in Santurce. During the spring gallego trees were found infested at Palo Seco and in one or two other localities.

Gomphrena dispersa Standley

Hymenia fascialis Cramer continued to be abundant on this weed at El Morro in San Juan, the larvae webbing together and skeletonizing the leaves.

Grape

Aphis illinoisensis Shimer, the black grape aphid, was present in small numbers on several vines in an arbor at Ponce early in March. It was also abundant on the tender shoots of a fairly large arbor at Puerto Real, Vieques Island, Sept. 8.

Grasses

Scapteriscus didactylus Scudder, the changa, did considerable damage to the St. Augustine grass in the fairways on the golf course at San Juan during dry weather in the spring of 1932.

Cicadella similis Walker (P.W.Oman det.) adults were very abundant on mallojillo or Para grass, *Panicum barbinode,* at Bayamón, May 15 (C.G.A.).

Collaris oleosa Dist. (Miridae, H.G.Barber det.) adults numerous on Para grass at Bayamón, May 15 (C.G.A.). Not in Wolcott's "List."

Zelus subimpressus Stal (H.G.Barber det.) adults numerous on Para grass at Bayamón, May 15 (C.G.A.). Not in Wolcott's "List."

Catorhintha guttula Fab. (H.G.Barber det.) a small number of adults on grass at Ponce, June 8 (R.G.O.).

Mormidea cubrosa Dallas (H.G.Barber det.) present in moderate numbers on grass at Ponce, May 13 (R.G.O.). Not in Wolcott's "List."

Psara phaeopteralis Guen. was reported on July 8 as injurious to "gramma" grass (St. Augustine grass) at Isabela. The grass on a large lawn was worse affected in the shade than in the sun (G.N.W.).

Guava

Leptomastix dactylopii Howard (Encyrtidae, Muesebeck det.). A pupa found in a guava fruit infested with *Anastrepha* sp. larvae (C.G.H.). Not in Wolcott's "List."

Coccus viridis Green, the green scale, moderately infesting the leaves of two bushes at Arecibo, Feb. 23 (A.S.M.).

Lechriops psidii Marshall (Curculionidae, Buchanan & Boving det.) larvae in mummied fruits at the Atlas Fruit Co. in Bayamón, Jan. 11 (C.G.A.). Apparently the second record from P. R., the type being the first.

Ormenis infuscata Stal (P.W.Oman det.) one adult on a guava leaf at Arecibo, Jan. 26 (R.F.).

Xyleborus sacchari Hopk. (Blackman det.) reported as infesting 2 out of 10 fruits examined at Cabo Rojo, Sept. 16 (A.G.H.).

Leptoglossus stigma Hbst. (H.G.Barber det.) abundant on the leaves of 3 guava bushes at Cidra, Nov. 13 and many adults on a bush at Trujillo Alto, Oct. 23 (A.S.M.).

Argyria diplomachalis Dyar (Pyralidae, Schaus det.) adults common on several bushes at Corozal, Mar. 18 (C.G.A.).

Heterothrips sericatus Hood (J.R.Watson det.) numerous in all of the blossoms on one bush at Barceloneta, June 14 (A.S.M.)

Metachroma sp., new to U.S.N.M. (H.S.Barber det.) found in small numbers on the leaves at Río Piedras, May 31 (C.G.A.).

Pulvinaria psidii Mask. (Morrison det.) moderately infesting the leaves at Lares, April 15 (R.G.O.).

Anthonomus inovatus Dietz (Buchanan det.) one adult on a fruit at Adjuntas, Apr. 11 (R.G.O.). Not in Wolcott's "List.".

Aleurodicus (*Metaleurodicus*) *minimus* Quaintance (G.B.Merrill det.) moderately infesting the leaves of 2 guava trees on the Denton Farm at Arecibo, Feb. 23 (C.G.A.).

Ormenis pygmaea Fab. (P.W.Oman det.). Adults in small numbers on the above trees (A.S.M.) and a moderate number of adults on a coffee tree at Arecibo on Mar. 8 (C.G.A.).

Hibiscus

Frankliniella cubensis Hood and *insularis* Franklin (J.R.Watson det.) adults in flowers at Mayagüez, March 20 (A.G.H.).

Haplothrips n. sp. (Watson det.) adults in flowers at Mayagüez, Mar. 20, (A.G.H.)

Inga Spp.

Tanaostigmodes portoricensis Cwfd. (Muesebeck det.) Heavily infesting pods of Guamá, *Inga laurina,* at Mayagüez, March 24. (A.G.H.) Previously known in P. R. only from the type.

Brenthia pavonacella Clem. A leaf-skeletonizer, badly infested the Inga shade trees thruout the coffee growing regions from fall to spring.

Carpolonchaea pendula Bezzi (Aldrich det.) adults reared from *Inga laurina* fruits, 25 per cent infested, at Jayuya, Jan. 18 (R.G.O.)

Jobo (*Spondias dulcis* Frost)

Haptoncus luteolus Er. and *Urophorus humeralis* Fab. (E.A. Chapin det.). All the fruits in a small package infested at Arecibo, Oct. 29 (R.G.O.). The latter not in Wolcott's "List."

MAHOGANY

Saissetia oleae Bern. and *Chrysomphalus dictyospermi* Morg. (Morrison det.) Very bad on a number of young trees at Forestry Station, Río Piedras, Mar. 29.

MALAY APPLE (*Jambos malaccensis*)

Coccus mangiferae Green, *C. acuminatus* Sign. and *Diaspis boisduvalii* Sign. (Morrison det.). Moderately infesting the leaves of two trees near Río Piedras, Jan. 11. (A.S.M.) The last not in Wolcott's "List."

Eucalymnatus tessellatus Sign. (G.B.Merrill det.). Same as above.

MAMEY (*Mammea americana* L.)

Toxoptera aurantiae Boyer (P.W.Mason det.) Young leaves heavily infested on small trees at Las Marías, Mar. 17 (A.G.H.)

Patara albidula Westw. (P.W.Oman det.). Adults common on one tree at Barceloneta, Mar. 22 (C.G.A.). Not. in Wolcott's "List."

MANGO

Selenothrips rubrocinctus Giard did considerable damage to the foliage of 1,000 nursery trees at the Station in August.

Asterolecanium pustulans Ckll. badly infested 3 trees at Río Piedras, Feb. 23.

MANGROVE

Psychonoctua personalis Grote badly infested a large area of mangrove swamp at Pt. Cangrejos near San Juan in April. The trunks and branches down to ground level were badly tunneled in nearly all the plants. Larvae of all sizes, pupae, and empty pupal skins were present. It was cut before maturity, causing a considerable loss in the yield of charcoal.

MARÍA (*Calophyllum antillarum* Britt.)

Eucalymnatus tessellatus Sign. (Morrison det.) lightly infested one tree near Río Piedras, Feb. 17 (C.G.A.)

Pseudococcus adonidum L. (Morrison det.) heavily infested the leaves of a tree near Río Piedras, Feb. 17. Not in Wolcott's "List."

Oxacis sp. probably new (H.S.Barber det.) Adults numerous on the leaves of several trees in Santurce, May (A.S.M.)

Toxoptera aurantiae Boyer and *Aspidiotus cocotiphagus* Marl. lightly infesting the young shoots on several trees in Santurce in May. First record for this host in P. R.

Icerya purchasi Mask. was abundant during the spring and early summer on a number of trees in Santurce.

Okra

Pectinophora gossypiella Saund. was found on July 10 infesting 10 out of 16 pods examined in a 1-acre planting at Trujillo Alto. The okra adjoined a field of about 1½ acres of cotton which showed about 85 per cent infested bolls. The okra plants examined were situated near the edge of the field next to the cotton. The infested pods were all mature, at least 3 or 4 inches in length, and each contained 1 or 2 larvae and several pupae were found within the pods. The cotton was an old field which had been infested for some time. In July (A.S.M.) okra planted experimentally at Isabela with cotton was also infested.

Diabrotica gramina Baly did considerable damage at the Station during August and moderate damage in a 1-acre planting in Trujillo Alto in July.

Aphis gossypii Glover was generally present but not very injurious at the Station during July.

Corythucha gossypii Fab. was found towards the end of the month in small numbers on the okra at the Station. The okra adjoins the pole limas on which the insects were breeding very abundantly. Only adults could be found but these were feeding to a noticeable extent, causing the characteristic yellowish stippled areas on the leaves.

Hyaliodes n. sp. (H.H.Knight det.) was present in some numbers in the same planting.

Oleander

Asterolecanium pustulans Ckll., was very abundant on a number of oleanders at Guánica on March 12. A plant was also heavily infested at Old Loíza, April 29 (A.S.M.).

Palm

Pinnaspis buxi Bouché, heavily infesting a palm at Pennock's nursery near Río Piedras, Feb. 17 (R.F.; Morrison det.). Not in Wolcott's "List."

Eucalymnatus tesselatus Sign. (Morrison det.) heavily infested a palm in a nursery near Río Piedras, Feb. 17 (C.G.A.)

Pseudococcus nipae Mask. moderately infested a palm in Santurce, May 23.

Panama Potato Tree

(*Solanum grandiflorum leiocarpum*)

Pseudococcus citri Risso (Morrison det.) lightly infested the leaves of 6 large trees at the Station at Río Piedras, Feb.; also 30 trees near Juncos, Jan. 25 (C. G. A.)

Pseudoparlatoria ostreata Ckll. A heavy infestation on the bark on one of the trees at Juncos.

Papaya

Toxotrypana curvicauda Gerst. Three medium sized fruits sent in by the Agricultural Agent at Jayuya with letter of June 1 stating that they came from a planting of about 50 trees just coming into production on the farm of Dr. Manuel Megías, Barrio Collores. All were fairly green, the 2 smaller moderate sized ones had been badly infested but the larger one was clean—only 1 or 2 dead larvae present. The papaya fruit fly was also sent in under date of July 8 by F. B. McClelland from the Mayagüez Experiment Station in a rather small and rather green fruit which contained 14 newly formed puparia and 1 full grown larvae (M. D. L.) One fruit was found infested at the substation at Isabela on July 3 and sometime during the month all of the fruit on several plants in a farm near Aguadilla were infested (G. N. W.) It was also found to be infesting the fruit of a number of plants on a farm near Ponce on Aug. 5. One fruit small and green and about 2½ inches long contained 20 larvae and another somewhat more mature and about 5 or 6 in. long contained 24 larvae; in both fruits the maggots were nearly to full-grown. The owner, Mr. Heraclio Girón, stated that during May and June nearly all of the fruits on his trees were infested, many so badly that they had to be thrown away. It was not found in several fruits cut open at the farm of Heraclio Girón near Ponce on Sept. 9. Mr. Girón stated that no infested fruits had been noticed for several weeks whereas formerly they had been heavily infested. As previously reported many infested fruits had been destroyed and I suspect that this resulted in greatly reducing the infestation in his planting.

Pseudoparlatoria ostreata Ckll. Heavily infested the fruits and stems of a papaya in San Juan, Jan. 13 (A. S. M.) It was abundant also on a number of trees in the Girón farm near Ponce, September.

Aulacaspis pentagona Targ. moderately infested the trees on the Girón farm. There was also a heavy infestation at the Isabela Substation in March.

Saissetia hemisphaerica Targ. also heavily infested the trees at Isabela.

Corythucha gossypii Fab. heavily infested the trees at Isabela during March and as is usual was observed in other places thruout the season.

Epitomiptera orneadalis Guer. (Schaus det.) A larva was found feeding on a papaya leaf, Mar. 8 (C. G. A.) Not in Wolcott's "List."

Nezara viridula L. (H. G. Barber det.). A light infestation of nymphs on papaya leaves near Río Piedras, Mar. 9 (C. G. A.).

Peas

Illinoia solanifolia Ashm (P. W. Mason det.). One winged adult was on a pea leaf at Cidra, Feb. 26 (A. S. M.) Not in Wolcott's "List."

Piezosternum subulatum Thumb. (H.G.Barber det) a small number of adults on garden pea leaves in a small patch on the Vivell farm at Trujillo Alto, Feb. 5 (A.S.Mills).

Agromyza pusilla Mg. adults reared from larvae making serpentine mines in pea leaves—a moderate infestation in a 2-acre planting at Cidra, Feb. 26 (A.S.M.; J. M. Aldrich det.). In Wolcott's "List" but without definite food-plant or locality.

Pepper

Aleurotrachelus trachoides Back (M. D. L. det.) moderately infested a number of plants at the Station at Río Piedras October and was noticed in April. It was also found August 17 to be badly infesting a house plant in Santurce.

Coreocoris batatas Fab. a light infestation on the leaves of a 5 acre pepper field at Vega Alta on Dec. 29 (A. S. M.; H. G. Barber det.).

Myzus persicae Sulz., was found to be lightly infesting the leaves of a 5 acre pepper field at Río Piedras on Feb. 8 (R. F.; P. W. Mason det.).

Disonycha laevigata Jacoby (H. S. Barber det.) lightly infesting the foliage and fruit of peppers and a moderate infestation on cucumber at Loíza on Feb. 7. There were 5 acres of peppers and 1 acre of cucumbers. (A. S. M.)

Chrysocharis parksi Cwfd. adults reared from pupae of *Agromyza pusilla* Mg. mining in pea leaves at Cidra, Feb. 26. 30 per cent of the dipterous pupae parasitized with this or another species. Not in Wolcott's "List."

Saissetia hemisphaerica Targ. (Morrison det.) lightly infesting the stems of 3 plants at the Experimental Farm at Trujillo Alto, Mar. 9 (C. G. A.).

Pigeon Pea

Etiella zinckenella Tr. (Heinrich det.) larvae were found in hampers of pigeon peas from Aguadilla, Lajas and Isabela for shipment to the States (A. G. Harley).

Heliothis virescens Fab. (Heinrich det.) larvae lightly infested hampers of pigeon peas to be shipped to the States from Lajas in March, Aguas Buenas and San Sebastión in January and from Aguadilla and Isabela (A. G. H.)

Icerya purchasi Mask. was found from April on, lightly to moderately infesting pigeon peas grown near infested citrus in Palo Seco and Bayamón.

Saissetia oleae Bern. (Morrison det.) so badly infested 4 bushes at Lajas on Feb. 13 that they were nearly dead (A. G. H.)

PINEAPPLE

Phyllophaga spp. larvae were reported on Apr. 13 by Eugenio Rivera, Agr. Agt. at Manatí, as having badly injured a number of pineapple fields at Vega Baja and Corozal during November and December.

Solenopsis geminatum Fab. also did considerable damage in the same place.

Cutworms (Noctuidae). J. E. Raymer reported (specimens submitted) on Feb. 15 that cutworms had been at that time working for about 3 weeks on 10 acres of his pineapples at Arecibo, causing a loss of about ⅓ of the plants by eating out large holes and destroying any market value of these plants.

Pomarrosa (*Jambos Jambos* L.)

Coccus acuminatus Sign. (Morrison det.) infesting many leaves of a pomarrosa tree at Corozal Feb. 9 (C. G. A.).

Saissetia oleae Bern. (Morrison det.) Infested many leaves of one tree at Corozal, Feb. 9 (A. S. M.)

Colpoptera maculifrons Muir (P. W. Oman det.) adults numerous on the leaves and stems at Bayamón, June 6 (A. S. M.)

Ormenis pygmaea Fab. (P. W. Oman det.) Many adults on the leaves of several trees at Corozal, Apr. 12. (C. G. A.)

Philaenus fuscovarius Stal. one adult on a pomarrosa twig at Bayamón, June 6 (C. G. A.)

Potato, Irish

Xylomyges eridania Cr. (Schaus det.) larvae were found to be eating many of the leaves in a 25 acre field of Irish potatoes on the Ellsworth farm at Cidra, Feb. 5 and a light infestation of the larvae was found on foliage on a 5-acre field of peppers on the Cabrera farm at Loíza on Feb. 8 (A. S. M.)

Cutworms (*Noctuidae*) had destroyed about 5 per cent of one-month old Irish potato plants on ½ acre at Aibonito by Feb. 3 altho many of the injured plants were sending up new shoots; Severo Pagán, Agr. Agt. at Aibonito, reported that 4 or 5 plantings in the vicinity were similarly affected (F. Chardón).

Diabrotica graminea Baly, was reported on Feb. 2 as doing considerable damage to both snap beans and Irish potatoes at Orocovis.

Aleurotrachelus trachoides Buck, badly infested a number of experimental Irish potato plants in the station greenhouses during April.

Nezara viridula L. (H. G. Barber det.). A small number of adults on the leaves of a 25-acre planting of potatoes on the Ellsworth farm at Cidra on Feb. 5 (A. S. M.).

Epitrix cucumeris Harr., the potato flea-beetle, was observed in moderate numbers in several places but not sufficient observations were not made to determine how much damage was done to the various plantings thruout the growing season.

Potato, Sweet

Agromyza ipomeae Frost was present thruout the year as usual in moderate numbers in all patches observed.

Euscepes batatae Waterhouse, was found lightly infesting one tuber in the public market at Puerta de Tierra, San Juan (R. F. & R. G. O.) Specimen sent in for determination on Apr. 6 by F. A. Velasco, Agr. Agent at Guayanilla, as badly infesting a small piece of sweet potatoes.

Spartocera batatae Fab. was abundant in all stages on a small patch of sweet potatoes in Hato Rey the end of April (F. Chardon). It was also reported as fairly abundant in all stages on several plants in Carolina on Nov. 2.

Cylas formicarius Fab. adults were not uncommon during 3 nights of collecting at light at Puerto Real, Vieques Island Sept. 25–27. Arturo Riollano, the local Agricultural Agent, stated that he had observed the insect as generally distributed and very injurious since he had been on the Island from Sept. 1930. It was generally distributed and as injurious as usual in P. R. thruout the year.

Cyrtocapsus caligineus Stal (Miridae, H. G. Barber det.) was found abundant on March 16 on a small patch of sweet potatoes in the Governor's garden in Río Piedras (C. G. A.). Not in Wolcott's "List".

Bemisia inconspicua. What is undoubtedly this whitefly was received from Miguel Díaz, Agr. Agt. at Arecibo under date of Mar. 26 on sweet potato leaves for identification.

Pumpkin

Margaronia hyalinata L. (Schaus det.) was feeding on pumpkin leaves in a small garden at Juncos on Jan. 25 (R. F.).

Rose

Icerga purchasi Mask., the cottony cushion scale, was found moderately infesting a number of large rose-bushes in a home garden in Santurce where Mr. Luciano of the Insular Plant Quarantine Office said it had been present for at least two years; this was the first record for the Island.

Metachroma antennalis Weise, a leaf-beetle, was received under date of Sept. 4 for determination from the Aguirre Sugar Co. The beetles were said to be present in enormous numbers and doing great damage to rose bushes. Out of over 1000 good sized rose bushes over 400 had been killed, the beetles first eating the flowers, next the leaves and finally gnawing off the bark of the woody parts. The beetles first appeared in the spring of 1929 and were present the following year and this, from April into September. It was stated that when disturbed the beetles drop readily. This species was originally described from Puerto Rico in 1885 by J. Weise in "Beitrag zur Chrysomeliden und Coccinelliden Fauna von Puerto Rico" Archiv. fur Naturgeshichte 51(1) : 155 and has apparently not been reported outside of the Island. Here it has been reported as rather badly attacking cotton at Quebradillas in June 1922 and was found between leaves and in spider nests on various plants on the beach at Arecibo in May 1923.

Cryptocephalus nigrocinctus Suff. was reported as lightly infesting about 200 rose bushes on the farm of Pedro Osuna in the Barrio of Quebrada Arenas near Río Piedras. The beetles eat the leaves but especially the buds.

Conotelus fuscipennis Er. (E. A. Chapin det.). A moderate number of the beetles on the flowers of 3 bushes at Adjuntas, June 19 (R. G. O.).

Frankliniella insularis Franklin (J. R. Watson det.) reported on June 1 by the local Agr. Agt. in Vieques Id. as doing great damage in 5 different farms and trouble is apparently general; it was the first the growers have noticed trouble in Vieques but stated that it had been previously noted in Mayagüez and other towns but was never reported. Buds attacked never open and flowers are totally spoiled, withered ones being full of thrips when opened especially at base of petals. Some gardens were 100 per cent infested and not a sound rose could be picked. Canna blooms were also attacked but not much damage done.

Silk Oak (*Grevillea robusta* Cunn.)

Asterolecanium pustulans Ckll., was found infesting badly a fair-sized silk oak near Bayamón on Apr. 10; a number of twigs and smaller branches had been killed by the attack.

Spider Lily (*Hymenocallis declinata*)

Xanthopastis timais Cramer (Heinrich det.). From Oct. thru Jan. the larvae were very abundant and doing considerable damage to the leaves on about 10 ornamental plants in a large nursery near Río Piedras on Oct. 10 (M. D. L. & A. S. M.)

Squash (See cucumber and melon)

Sugar Cane

Diatraea saccharalis Fab. was reported in Sept. by I. Flores Lugo, Agr. Agt. of Carolina as causing a large percentage of "dead hearts" on about 4 acres out of about 200 acres of cane in the barrio Cangrejos Arriba of Carolina. The cane had been planted in April or May; this worse affected part had to be plowed up and replanted. The insect was not very abundant on Vieques Island during an inspection trip on March 23 due probably to the unduly high rainfall for the Island (72 ins.) of last year. (M. D. L.) The moth-borer however was worse according to S. C. McCall on the 1931 crop in

Vieques Island than on the 2 previous years' crops under his observation (a total of about 3,500 acres). He stated that Japanese cane, usually supposed to be somewhat less infested than other varieties was however the worst infested of all during this past year.

Pseudococcus boninsis Mask. (= *calceolariae* of authors) was not uncommon on sugar cane in several localities examined in company with C. E. Pemberton on Vieques Island on March 23. (M. D. L.; Pemberton det.)

Pseudococcus sacchari Ckll. was moderately common on both Uba and Crystalina (a little more so on latter apparently) in several sections examined on Vieques Island on an inspection trip on March 23. (M. D. L.)

Aspidiotus sacchari Ckll. was moderately common on a large lot of Uba cane being loaded at the dock on Vieques Island, examined on March 23. (M. D. L.)

Dyscinetus barbatus Fab. adults of a species known to injure cane were absent at lights at Isabela during the whole of July but began appearing again at lights on Sept. 2 at Isabela (G.N.W.)

Ligyrus tumulosus Burm. were abundant at light during July at Isabela and many were being eaten by the imported toad, *Bufo marinus* L. (G. N. W.) An adult was taken at a light in Santurce, Mar. 27 (A. S. M.; E. A. Chapin det.)

Phyllophaga vandinei Smyth. Scattering male adults were collected on Aug. 11 and 12 at Isabela but by the end of the month they were even yet not common there (G. N. W.)

Strataegus quadrifoveatus P. de B. Two adults of the coconut rhinoceros beetle were received under date of July 16 from Alberto Correa from Utuado with the statement that they were found eating the shoots of young cane plants; the injury was noted in several places near Utuado (M. D. L. & F. S.).

Dyscinetus barbatus Fab. Adults of this Scarabeid beetle, an occasional minor enemy of cane were observed in small numbers at lights at Hato Rey on Aug. 31 (M. D. L.). At Isabela adults were not observed at lights thruout August and had not been seen at lights since June 8 (G. N. W.).

Remigia (Mocis) repanda Fab., the sugar cane looper, defoliated a small area of Para or malojillo grass (*Panicum barbinode*), young plant cane and half grown elephant grass (*Panicetum glaucum*) during July at Isabela (G. N. W.)

Sipha flava Forbes, the yellow cane aphis, was observed doing considerable damage in a number of large plantings of young to fairly large cane near both Aguirre and Santa Isabel on Aug. 22. Mr. Foss,

Ass't. Field Manager of the Aguirre Sugar Co. stated on that date that during all of July and Aug. there had been a rather general tho fairly light infestation thruout nearly all of the Company's extensive plantings—this in spite of the fact that the rainfall had been greatly in excess of normal. The insect was present to some extent on Vieques Island on Sept. 27 but S. C. McCall, local Mgr. of the United Porto Rican Sugar Co. on Vieques said it had been absent during the past year as far as he could observe. Its absence or at least scarcity was probably due to much more than normal rainfall on that Island. It was reported on Oct. 7 by Dr. T. Bregger of the Ins. Exp. Station to be fairly abundant on about 2 acres of 3 or 4 months' cane (old ratoons of POJ 2878) on the Station grounds; this in spite of recent abundant rains. He also reported on Oct. 1 that a field of Uba cane, ratooned 4 or 5 months previously, was conspicuously yellow from the road at Jayuya despite much recent rain there also. Under date of Oct. 22, a grower, Enrique López Delgado, wrote that especially in the barrio Miradoro of Cabo Rojo the yellow aphis had by then destroyed almost 25 per cent of the plantings and of the remainder about 50 per cent were infested. He reported the infestation as extending into the other cane growing section of Sabana Grande, San Germán, Lajas, Hormigueros and Mayagüez. In Miradoro not only Japanese cane was attacked but also BH 10(12) and POJ 2878. At the Station a 2 acre planting of 2 months' old ratoons POJ 2878 was lightly infested early in June despite 13 ins. rainfall during the previous month and another planting of the same size and variety was considerably infested thruout all of Feb., Mar. and Apr. with only 6 ins. rainfall for the 3 months.

Tamarind

Sitophilus linearis Hbst., the tamarind pod-borer, adults and larvae, found feeding in one pod in a crate of tamarinds for shipment to the States, Feb. 25 (C. G. A.; Buchanan det.).

Myelois ceratoniae Zell. (Heinrich det.) 20 per cent of about 100 pods examined at Trujillo Alto found infested with larvae; adults were reared (A. S. M.) Not in Wolcott's "List".

Tamarix sp.

Saissetia hemispherica Targ. (Morrison det.) fairly abundant on a couple of small trees of Tamarix sp. at the Forestry Station at Río Piedras on Mar. 29 (M. D. L.)

Tobacco

Practically no definite observations were made on tobacco insects during the year but reports would indicate that the more important insects were present in about the usual numbers. Flea beetles were bad on experimental plantings at the Station during the dry spell thruout Feb. Mar. and April.

Tomato

Scapteriscus didactylus Latr., was doing considerable damage to young tomato plants in a 3-acre field of tomatoes and to a 3-acre planting of eggplants on Nov. 6 at Loíza; grass land adjoined these fields (A. S. M.).

Myzus persicae Sulz. (P. W. Mason det.) was observed very lightly infesting the foliage of a 3-acre field of tomatoes at Loíza on Nov. 6 (A. S. Mills).

Cyrtopeltis varians Dist. (H. G. Barber det., Miridae) was found lightly infesting the foliage of a 3-acre field of tomatoes at Loíza on Nov. 6 (A. S. M.). Not in Wolcott's "List".

Agallia albidula Uhl. (P. W. Oman det.) lightly infested the leaves of tomatoes at Loíza, Nov. 6 (A. S. M.).

Grasshoppers (*Locustidae*) did considerable injury to several large tomato plants grown for experimental purposes in the greenhouse at the Station during the latter of September. The injury was by the young green nymphs.

Xylomyges eridania Cr. (Schaus det.) larvae moderately infesting tomato fruits, which were being eaten out at the Vivell farm at Río Piedras, Feb. 15 (R. F.)

Atherigona excisa Thom., many larvae in a decayed tomato from Isabela on Jan. 19 (C. C. A.; C. T. Greene).

Empoasca fabalis DeL., moderately infested a 3-acre field of tomatoes on Nov. 6 at Loíza (A. S. M.; P. W. Oman det.).

Flea beetles were bad on tomatoes at the Station in Río Piedras during the dry spell thru Feb., Mar. & Apr.

Epitrix cucumeris Harr. (H. S. Barber det.) was reported in large numbers on a number of plants on a farm at Adjuntas in March (R. G. O.)

Chaectocnema apricaria Suffr. (H. S. Barber det.) in moderate numbers on tomato plants at Jayuya on June 14 (R. G. O.)

Tree Fern

Pseudococcus adonidum L. (Morrison det.) found badly infesting the young fronds of two plants at Mayagüez, Mar. 18 (A.G.H.)

Tropical Almond (*Terminalia catappa* L.)

Ormenis marginata Brunn. (P. W. Oman det.) 3 adults resting on the leaves of one tree examined on Mar. 15 at Río Piedras (A. S. M.) and a small number of adults on the leaves of one coffee bush at the Demonstration Farm at Arecibo on Mar. 8 (C. G. A.)

Megalopyge krugii Dewitz, the puss-moth, was abundant on a number of trees on Apr. 21 near Arecibo (F. S.)

Monobelus fasciatus Fab. Membracidae—a small number of adults on the flower-stalks of several trees at Bayamón on March 21 (R. F.; P. W. Oman det.)

Attelabus sexmaculatus Chev. (L.L.Buchanan det.) One adult on a flower-stalk in examining several "almendro" trees at Bayamón on Mar. 21 (C. G. A.)

Urophorus humeralis Fab. and *Stelidota geminata* Say (Nitudilae, E. A. Chapin det.) feeding in the fruits at Arecibo, Oct. 10 (R. G. O.) and at Añasco, Sept. 29 (A.G.H.) respectively.

Haplothrips gowdeyi Fkln. (J. R. Watson det.) in small numbers on the leaves at Santurce, June 11 (A. S. M.). Apparently the first record for P. R.

Cicadella sirena Stal. (P. W. Oman det.) adults numerous on leaves, Arecibo, May 20 (C. G. A.).

Chalepus sanguinicollis L. (H. S. Barber det.) a small number of adults at base of flower-stalks, Arecibo, May 24 (A. S. M.).

Vanilla

Apodrusus wolcotti Marshall (Curculionidae, L. L. Buchanan det.) A light infestation of adults on flowers and stems found while examining 40 plants at Adjuntas, May 17 (R. G. O.)

Vitex altissima

Saissetia oleae Bern. was fairly abundant on a single small tree at the Forest Service Station at Río Piedras on Mar. 28 (M. D. L.)

Waterlily

Pentalonia nigronervosa Coq., a waterlily aphid, was reported by Dr. N. L. Britton as considerably infesting several plants at San Ger-

mán on Dec. 29 and in March he submitted specimens from the same place (F. Seín det.) In February F. Seín reported several plants killed at Santurce, the leaves being badly infested and curled.

West Indian Laurel (*Ficus nitida* Thumb.)

Gynaikothrips uzeli Zimm. was more or less abundant as usual on nearly all trees examined in various places.

Ischnaspis longirostris Sign. (Morrison det.) was found heavily infesting the leaves of several large trees on the Plaza in Caguas during April.

Ceroplastes floridensis Comstk. (Morrison det.). A light infestation on the leaves of the same trees.

Macrotracheliella laevis Champ. (Anthocoridae, H. G. Barber det.) found feeding in moderate numbers on the thrips mentioned above. Not in Wolcott's "List."

Icerya montserratensis R. & H. common on several of the trees in the Plaza at Caguas but they did not seem to be quite as abundant as last year; this may have been because the observations, such as were made, were during the periods of greater rainfall.

Cattle

Haematobia irritans L. the horn-fly, was observed to be very abundant on all the oxen on the Island of Vieques during a short trip there in September. S. C. McCall, manager of the local Sugar Co. stated that it had been worse this year than usual. One bull was covered with flies and in a greatly weakened condition. It was reported later that this one and several others had died from the effects of the bites. The considerably greater rainfall during some months past could have hardly been responsible for the great increase in numbers of this pest for in Puerto Rico proper it is ordinarily worse on the South Coast where the rainfall is much less than on the North Coast.

For several additional external parasites of animals see the Report of the Veterinarian in Rept. P. R. Agr. Exp. Sta. for 1931.

Man

Culex nigripalpus Theo. (Alan Stone det.) adults collected at light in hotel room in Mayagüez on May 1 (C. G. A.).

Chrysops variegatus Deg. was occasionally annoying at Río Piedras and one or two other localities.

Miscellaneous Records

The following species have presumably not heretofore been recorded from Puerto Rico:

Argyria lacteella Fab. (Pyralidae, Schaus det.) An adult caught at light, Bayamón, Apr. 17 (C. G. A) and another on a lima bean leaf in a field at Loíza, Feb. 7 (A. S. M.).

Psara detritalis Guen. (Pyralidae, Schausdet.). An adult taken on a fruit in a hamper of peppers from Humacao, Feb. 4 (C. G. A.).

Mocis disseverans Wlk. (Noctuidae, Schaus det.). Adults taken at light at Bayamón, Apr. 17 and May 15 (C. G. A.).

Monodes agrotina Guen. (Noctuidae, Schaus det.) at light Bayamón, May 15 (C. G. A.)

Brachymeria ovata Say (Chalcididae, Musebeck det.). An adult reared from a lepidopterous pupa at Mayagüez, June 24 (A. G. H.). It is interesting to note that this species has been recorded from New York State where it has been reared from *Vanessa antiopa* (Cornell Univ. Agr. Exp. Sta. Mem. 101, 1928).

Nasutitermes costalis Holmg. (T. E. Snyder det.) collected at light at Bayamón, June 12 (C. G. A.).

Microbracon hebetor Say (Braconidae, Musebeck det.) in a package of pigeon peas being sent to the States from Ponce, May 18 (R. G. O.)

Chlorion (Ammobia) singularis Smith (Larridae, G. A. Sandhouse det.) collected in the automobile at Guánica No. 13 (A. S. M.).

Colyostichus biannulatus Mayr. (Callimomidae, Musebeck det.) Moderately infesting the fruits of Piper sp. at Cidra, Nov. 13, (R. G. O.).

Calliephialtes n. sp. (Ichneumonidae, R. A. Cushman det.) An adult on a grapefruit leaf at Añasco, May 2 (C. G. A).

Ceratomegilla innotata Muls. (Coccinellidae, E. A. Chapin det.) on a pepper leaf at Vega Alta, Nov. 24 (A. S. M.).

Monanus concinnulus Wlk. (Cucujidae, W. S. Fisher det.) on a window in a dining room, San Juan, Apr. 24 (C. G. A.).

Disonycha spilotrachelus Blake (Chrysomelidae, H. S. Barber det.) adults on an unknown weed, Santurce, June 29 (C.G.A.).

Stephanoderes braziliensis Hopk. (Scolytidae, Blackman det.) 1 adult in a decayed flower-stalk of banana, Bayamón, May 15, (C. G. A.)

Gnathocerus cornutus Fab. (Tenebrionidae, E. A. Chapin det.) An adult on a leaf of watercress in a dining room in San Juan, Feb. 21 (C. G. A).

Cylindera flava Fab. (Cerambycidae, W. S. Fisher det.). An adult on a lima bean blossom, Loíza, Dec. 1 (A.S.M.).

Sapromyza picticormis Coq. (Sapromyzidae, Aldrich det.) adults common on grapefruit at Arecibo, Mar. 1 (R. F.).

Sapromyza slossonae Coq. (Aldrich det.) resting on orange fruit at Pueblo Viejo, Feb. 13 (C. G. A.)

Conoderus bifoveatus Beauv. (Elateridae, W. S. Fisher let.) 2 adults on a flower-bud of *Terminalia catappa* at Barceloneta, May 10 (A. S. M.)

Sitodrepa panacea L. (W. S. Fisher) collected at light in a hotel room, Mayagüez, May 1 (C. G. A.)

Cactylosternum abdominale Fab. (Hydrophilidae, L. L. Buchanan det.). 1 adult at hotel light Mayagüez, May 1 (C.G.A.).

Siphunculina signata Wollaston (Chloropidae, Aldrich det.). An adult on a dining room window in San Juan, Apr. 1 (C.G.A.)

Leucomelina n. sp. (Anthomyidae, Aldrich det.). One adult on trail up El Yunque Mountain, near Luquillo, Mar. 13 (A.S.M.).

Ceropsilopa n. sp. (Ephydridae, Aldrich det.). Adults on under side of grapefruit leaves at Arecibo, Apr. 5 (C.G.A.).

Lasiochilus fusculus Reut. (Anthocoridae, H.G.Barber det.) adults on a decayed flower-stalk of banana at Bayamón, May 15 (C.G.A.).

Exitianus obscurinervis Stal. (Cicadellidae, P.W.Oman det.) 3 adults on leaves of an unidentified weed at Arecibo, June 7 (C.G.A.).

Megoura n. sp. (Aphididae, P.W.Mason det.). A moderate infestation on 5 plants (plant unrecorded) examined in Santurce, June 20 (A.S.M.).

Pycnoderes heidemanni Reut. and *Polymerus cuneatus* Dist. (H.G. Barber det.) collected by sweeping weeds in Santurce, June 29 (C.G.A.).

Coreocoris batatas Fab. (Coreidae) and *Engytatus geniculatus* Reut. (Miridae, H.G.Barber det.) 1 adult each at Añasco, May 2 (C.G.A.).

Oncopeltus fasciatus Dall. (Lygaeidae, H.G.Barber det.). 1 adult on a flower at Arecibo, Apr. 22 (C.G.A.).

Anasa scorbutica Fab. (H.G. Barber det.) a squash bug, was observed lightly infesting a 2-acre planting of squash at Vega Alta, Nov. 24 (A.S.M.).

The following records, altho not entirely new to Puerto Rico, are those of insects known heretofore only from the type material from Puerto Rico or for the most part from only one or two previous records:

Xestocephalus maculatus Osb. (Cicadellidae, P.W.Oman det.) collected at light in a hotel in Mayagüez (C.G.A.). Known only from types taken on Inga sp. on the Cayey road at about 2,000 ft. elevation.

Cicadella coffeeaphila Dozier (P.W.Oman det.). Several adults on an unidentified plant on the trail up El Yunque Mountain (A.S.M.).

Agallia pepino DeL. & Wolc. (Cicadellidae, P. W. Oman det.) collected at light in Mayagüez, May 1 (C.G.A.). First record from the West end of the Island.

Thamnotettix colonus Uhl. (Cicadellidae, P.W.Oman det.) collected at light in Mayagüez, May 1 (C.G.A.). Recorded by Osborn from several localities but not from the coast at the west end of the Island.

Deltocephalus nigripennis DeL. (Cicadellidae, P.W.Oman det.) at light in Mayagüez, May 1 (C.G.A.). Known only from type male from Boquerón.

Protalebra lenticula Osb. (Cicadellidae, P.W.Oman det.) 2 adults at light, Bayamón, May 17 (C.G.A.). Known only from type material from Coamo, Jan. 1929.

Psyllia minuticona Cwfd. (Psyllidae, P.W.Oman det.) at light, Bayamón, May 15 (C.G.A.). Only previous records is "common on *Inga vera* at Lares 1922 and thruout the coffee districts. (Wolcott's "List" p. 274).

Colpoptera brunnea Muir (Fulgoridae, P.W.Oman det.) at light, Mayagüez, May 1 (C.G.A.). Osborn says probably one of the forms listed by Wolcott under Carda sp. from several other localities; types from Utuado, Toa Alta and Ciales.

Acinopterus angulatus Laws. (P.W.Oman det.). Caught by sweeping weeds, Santurce, June 29 (C.G.A.). Only record for the North Coast.

Euryopthalmus obovatus Barber (Pyrrhocoridae, H.G.Barber det.) common as adults on branches and trunk of three orange trees at Peñuelas, Jan. 26 (R.G.O.). Apparently known from P. R. only by a female paratype.

Zelus longipes L. (Reduviidae, H.G.Barber det.). An adult resting on a guava leaf at Trujillo Alto, Oct. 23 (A.S.M.). Previously recorded from Trujillo Alto in 1912; elsewhere only in the mountains.

Icerya montserratensis R. & H. reported by Wm. Barbour, Chief Insular Forester, as found moderately infesting on May 4 a small

unknown native tree on the north slope of the Luquillo Mountains about 5 miles south of Luquillo at about 750 feet altitude.

Haptonchus luteolus Er. (Nitidulidae, E.A.Chapin det.) 3 adults in a decayed star apple fruit, Arecibo, Apr. 22 (C.G.A.). Little known in P. R.

Lobiopa insularis Cast. (Nitidulidae, E.A.Chapin det.) A great many adults on the bark of a tree of *Petitia dominguensis* at Arecibo, Jan. 26 (C.G.A.) Little known in P. R.

Chysobothris megacephala C. & G. (Buprestidae, M.D.L. det.) An adult flew into the car of Raphael Rodríguez of the College of Agriculture while passing thru Isabela, May 18. In Wolcott's "List" as collected in 1922 but "date and locality unknown".

Xyleborous affinis Eichhoff (Scolytidae, M.W.Blackman det.) An adult at light in a hotel, Mayagüez, May 1 (C.G.A.) Listed from P. R. previously only by Leng & Mutchler.

Platypus rugulosus Chapuis. (Scolytidae, M.W.Blackman det.) 2 adults at light in a hotel in Mayagüez, Apr. 30 (C.G.A.). Only previous record is at light at Mameyes in 1913.

Lema dorsalis L. (Chrysomelidae, H.S.Barber det.) Adults numerous on the leaves and flowers of an unkonwn weed at Arecibo, May 24 (C.G.A.). Previously listed from Aibonito, Coamo, Boquerón and Caguas.

Disonycha laevigata Jacoby (Chrysomilidae, A.J.Mutchler det.) Often very injurious to beets, swiss chard, etc., was reported by S. Molinary, Agr. Agt. at Carolina as very abundant on the common weed "Jamón con huevo" (*Achyranthes Bettzickiana*) at Loíza during October; many adults were submitted for determination. Apparently a new food-plant for P. R.

Panagaeus quadrisignatus Chev. (Carabidae, L.L.Buchanan det.) Adults at light in Bayamón, Apr. 17 (C.G.A.). Previously listed only from Aibonito and Guánica.

Callopisma borencona L. & M. (Lampyridae, H.S.Barber det.). An adult on a pomarrosa leaf at Bayamón, Mar. 21 (R.F.). Not many locality records.

Callopisma emarginata L. & M. (Lampyridae, H.S.Barber det.). A small number of adults on orange fruits at Peñuelas, Jan. 26 (R.G.O.). Previously listed only from type material from: Mayagüez, Adjuntas, Río Blanco Valley and Utuado.

Psyllobora nana Muls. (Coccinellidae, E.A.Chapin det.). Two adults on a cashew nut leaf, Santurce, April 6 (A.S.M.). Little known in P. R.

Callosobruchus chinensis L. (Bruchidae, H.S.Barber det.). An adult on a pepper fruit in a crate from Isabela, Apr. 4 (C.G.A.). Apparently not often recorded in P. R. (See also under bean).

Eurema euterpe Mén. (Pieridae, Schaus det.). A small number of adults at Cidra, Feb. 26 (A.S.M.). Apparently little known in P. R. but easily confused with *E. portoricensis* according to Dr. Forbes.

Atrytone vitellius Fab. (Hesperiidae, Schaus det.). Caught in a net at Río Piedras, June 22 (C.G.A.). Apparently not recorded since 1922 but probably common in various localities. The larva is known as a minor pest of sugar cane.

Calisto nubila Lathy (Satyridae, Schaus det.). 3 adults caught on the trail up El Yunque mountain, back of Luquillo Mar. 13 (A.S.M.). Apparently only a few previous records but according to Dr. Forbes undoubtedly common and widely distributed.

Dichomeris manellus Mösch. (Gelechiidae, as *Dichomeris,* Busck det.). An adult on a pomarrosa leaf at Barceloneta, Mar. 22 (A. S.M.). Apparently known heretofore from P. R. only from type material, without definite locality. Forbes, following Meyrick lists this as a *Trichotaphe* (Sci. Surv. P. R. 12:121, 1930).

Lymire flavicollis Dewitz (Syntomidae, Schaus det.). An adult reared from a pupa on a cucumber leaf at Caguas, Jan. 25 (R.F.). Previously recorded only from Naguabo, Coamo, Lares (Seín) and Palmas Abajas, back of Guayama (Hoffman).

Pseudosphinx tetrio L. (Sphingidae, Heinrich det.). One larva from Mona Id. (A.S.M.) which is apparently the first record for that place.

Epistor lugubris Drury (Sphingidae, Schaus det.). Adult at light in Santurce in December (A.S.M.). Recorded only from Río Piedras and Lares.

Syngrapha egena Guen. (Noctuidae, Schaus det.). An adult on a lima bean leaf, at Cidra, Feb. 5 (A.S.M.). Only previous published record is from Cayey but specimens are in the Ins. Exp. Sta. coll. also from Comerío.

Melipotis januaris Guen. (Noctuidae, Schaus det.) An adult at light in San Juan, June 23 (C.G.A.). Apparently but little known in P. R.

Leucinodes elegantalis Guen. (Pyralidae, Schaus det.). Adult at light in Bayamón, May 15 (C.G.A.). Previously only recorded from P. R. without definite locality or date but specimens are in the Cornell Univ. coll. (Forbes det.) from 7 different widely separated localities by various collectors.

Lipocosma hebescalis Mösch. (Pyralidae, Schaus det.). An adult at light in Bayamón, Apr. 17 (C.G.A.). Previously recorded only from the type but Dr. Forbes collected several specimens in 1930.

Cataclysta miralis Mösch. (Pyralidae, Schaus det.). An adult at light in Bayamón, Apr. 17 (C.G.A.). Previously recorded only from the type material, without definite date or locality but Dr. Forbes found it common on El Yunque and also collected it at several other localities in 1930.

Crambus fissiradiellus Wlk. (Pyralidae, Schaus det.). An adult at light in Bayamón, Apr. 17 (C.G.A.). Previously recorded only from P. R. without definite date or locality.

Crambus ligonellus Zell. (Pyralidae, Schaus det.). An adult at light in Bayamón, Apr. 17 (C.G.A.). Previously recorded only from "P.R." but Dr. Forbes collected a number of specimens in 1930.

Samia ecclesialis Guen. (Pyralidae, Schaus det.). 2 adults at light in San Juan, Apr. 24 (C.G.A.). Previously recorded from "P.R." but according to Dr. Forbes this is abundant and general and there are many specimens in the Cornell University collection.

Lamprosema ebulialis Guen. (Pyralidae, Schaus det.). An adult at light in Santurce, Dec. 4 (A.S.M.). Not previously recorded from P. R. but there are specimens in the Cornell Univ. coll. from El Yunque (Forbes, 1930) and Lares (Seín, 1930 or 1931).

Hunterellus hookeri Haw. (Encyrtidae, Mueseback det.), found on a window in a dining room in San Juan, Apr. 2 (C.G.A.). Only 2 previous records from P. R.

Christolimorpha plesius Vier. (Ichneumonidae, R.A.Cushman det.). An adult on a leaf of Psidium sp. at Mayagüez, June 12 (A.G.H.). Only previously known from type.

Notogonidea vinulenta Cress. (Sphecidae, S.A.Rohwer det.). Adults numerous on the blossoms of many grapefruit trees at Barceloneta, May 10 (C.G.A.). Only 1 previous record—from Mayagüez (Van Zwaluwenburg's typewritten "List" of 1914).

Polistes crinitus var. *americanus* (Vespidae, G.A.Sandhouse det.). Adults numerous on the blossom of many grapefruit trees at Barceloneta, May 10 (C.G.A.). Apparently not before recorded from the north coast.

Polistes major Beau. and *Sceliphron coementarium* Drury (F. Seín det.). Sent in from Bayamón by F. Joglar Rodríguez from a grapefruit tree, Aug. 6. Both of these species were apparently unknown in the Island until this past year.

Exomalopsis globosa Fab. (Anthophoridae, G.A.Sandhouse det.). 1 adult in an automobile at Arecibo, Apr. 22 (C.G.A.). Previously

known in P. R. from only one record "tunneling in hard clay at Guánica (G.B.Merrill)."

Cycloptilum antillarum Redt. (Gryllidae, A. N. Caudell det.). A small number of nymphs on the leaves of a maga tree, *Montezuma speciosissima,* at Arecibo. May 24 (A.S.M.) an adult found in a house in Santurce, Oct. 20 (A.S.M.). Apparently little known in P. R.

Neorandania chalybaea Wied. (Stratiomidae, C.T.Greene det.). Many adults resting on grapefruits at Arecibo, Apr. 5 (R.F.). Little known in P. R.

Tabanus hookeri Knab. (A.S.M., Alan Stone det.). One adult, at light at Santurce, Feb. Not in Wolcott's "List" but recorded from Vieques Id., P. R. in Curran's First Suppl. to Diptera of Porto Rico. Described from Porto Rico (Ins. Insc. Men. 3(4) : 48, 1919).

Volucella pallens Wied. (C.T.Greene det.). An adult resting on a *Termalia catappa* leaf, Arecibo, July 27 (M.Kisliuk) and an adult on an orange at Peñuelas, Feb. 25 (R.G.O.). Little known in P. R.

Chrysotus excavatus VanD. (Dolichopodidae, Aldrich det.). Adults on grapefruit in small numbers at Arecibo, Mar. 1 (C.G.A.). Previously recorded only from Aibonito.

Psilopus diffusus Wied. (Dolichopodidae, C.T.Greene det.) Adults resting on fruits in small numbers on several sour orange trees, Arecibo, Feb. 23 (C.G.A.). In Wolcott's "List" but without definite locality.

Proctacantha rufiventris Macq. (Asilidae, C.T.Greene det.). 1 fly resting on a tropical almond leaf, Arecibo, July 27 (Max Kisluik). Stated by Wolcott to be "quite common" but only actually recorded from 2 or 3 definite localities.

Sigaloessa bicolor Lw. (Oscinidae, Aldrich det.). A moderate number of adults resting on leaves of several banana plants at Bayamón, Apr. 8 (C.G.A.). Recorded only from Coquillett's original record published in 1900.

Gonia crassicornis Fab. (Tachinidae, Aldrich det.) was reared from a cocoon of the Noctuid *Xylomyges eridania* Cr. Previously recorded by Jones and Wolcott (Jour. Dept. Agr. P. R. 6(1) : 47, 1922) as a parasite of *Laphygma frugiperda* S. & A.

Archytas antillicola Curran. (Tachinidae, Aldrich det.). One adult on trail up El Yunque mountain, Mar. 13 (A.S.M.). Known only from the types (1927) altho these were from several localities, mostly at the higher elevations also.

Drosophila repleta Woll. (Aldrich det.) Adults on window in dining room in San Juan, Apr. 1 (C.G.A.). Previously recorded only from 2 specimens, Santurce 1914.

THE RELATION OF ANTHER COLOR AND THE PROPORTIONS OF STARCH FILLED POLLEN GRAINS IN THE SUGAR CANE

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The arrowing or flowering of most commercial sugar cane varieties in Puerto Rico takes place from the last week in October to the middle of January. The most effective period for crossing work extends from the middle of November to mid-December. Previous to this period the numbers of arrows are limited and after this period the condition of the arrows is not so good. Emergence from the sheath or boot is slower, in many instances incomplete, irregular, and slower.

Within the limits of the material available it is desirable to obtain as many new combinations and as large a number of crosses within the combinations as possible. Where trained help is scarce it is desirable to have some rapid method of determining pollen fertility of the varieties to serve as males. Bannier (1) describes a suitable method but it requires more personnel than the writer has had available in carrying out his work at Río Piedras, P. R. During the years 1929 and 1930 the arrows and attached canes were cut in the late afternoon, brought to the laboratory, and placed in quart Mason jars with water and a quantity of 6 per cent H_2SO_3 sufficient to approximate a 1:3000 solution. The following morning when pollen shedding took place, samples were collected on slides and examined microscopically in a saturated solution of iodine in chloral hydrate. Counts of iodine positive and iodine negative staining pollen grains were recorded. Anther color was noted under field conditions. In 1931 with a larger number of unknown potential males coming into bloom it was realized that our methods would not permit us to do much more than make pollen observations if the methods were not changed. Hence the arrows were cut without the attached canes. Small samples were examined microscopically from florets unopened but just below those which shed pollen for that day. The arrows were then placed in sheets of newspapers between blotters and dried for 10 days to two weeks. Blotters were changed every 2–5 days. Further samples were taken at a later date and comprise the data presented in table II.

Pollen counts

In crossing campaigns previous to 1930 it was noted that varieties with purple or purplish anthers seemed to give larger counts of iodine positive grains than those with yellow. In order to observe any relation between degree of color of anther and iodine reaction a number of varieties were examined. They were grouped into three classes with respect to color of anthers. In 1930 pollen counts were made of 15 varieties. All arrows were taken from field plantings unless otherwise noted.

Table I

RELATION OF ANTHER COLOR AND IODINE REACTION 1930

Variety	No. of pollen grains counted	Per cent Iodine Positive in		
		Purple Anthers	Med. Pur- Anthers	Yellow Anthers
P.R. 358	1069		37.04	
Co-281	1487		54.67	
SC 12-4 (Drums)	1439		57.19	
SC12-4	1335	89.97		
POJ-2878	1399		82.13	
P. R.-492	205		56.10	
POJ-2725 (Collection)	1110			3.93
POJ-2725	No count.			Less than 1
Kassoer	740	51.61		
Tuc-472	1349	72.45		
POJ-2364	869			1.62
Badilla	555		49.91	
POJ-36	No count.			Less than 1
D-1135	1204	66.03		
Tuc-450	613	66.07		
Tuc-454	513		51.85	
T-2009	1028		77.62	
Average		71.74	60.25	2.91
Maximum		89.97	83.13	3.93
Minimum		51.61	37.04	1.62

The assistance of Miss Ana Molina, Inst. in Biology, U. P. R., in making most of the counts in table I is hereby acknowledged.

In general the data seem to show that intensity of purple coloration of the anthers is some indication of the fertility of the enclosed pollen grains. Undoubtedly as between yellow and purple of medium or better, the latter are to be preferred for use as males. It is interesting to note that in the case of SC 12-4, pollen from field grown plants had a higher percentage of iodine positive pollen grains and more intense purple color than those grown in drums.

In 1931 notes were available on 41 varieties and they were grouped according to anther coloration into 4 classes. The data presented in table II are based on the sum of the counts of the first and second samples as mentioned above. There is essentially no difference between the counts made in November 1931 and those made in August

1932. The correlation coefficient between the two series of observations was $0.642 \pm .059$. See table II.

TABLE II

RELATION OF FRESH AND DRY FLOWERS

Percent Positive November 1931	Percent Positive August 1932									
	0–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80	81–90	
0–10	14	1	1	.....	1	.....	.....	.....	.....	17
11–20	1	.....	.....	1	.....	.....	.....	.....	.....	2
21–30	.....	.....	3	2	1	.....	.....	.....	.....	6
31–40	1	.....	.....	1	1	.....	.....	.....	.....	3
41–50	.....	.....	.....	1	2	.....	1	.....	.....	4
51–60	.....	.....	.....	.....	3	3	.....	.....	.....	6
61–70	.....	.....	.....	.....	1	.....	.....	1	1	3
71–80	.....	1	1	.....	.....	.....	.....	.....	.....	2
	.....	.....	.....	.....	.....	1	.....	1	.....	2
	16	2	5	5	9	4	1	2	1	45

NOTE: The discrepancy in total observations between tables II and III is due to the fact that anther color determinations were lacking in 4 cases.

TABLE III

RELATION OF ANTHER COLOR AND IODINE REACTION 1931

Purple Anthers			Med. Purple Anthers			Tinged and Light Purple Anthers			Yellow Anthers		
Variety	No. Pollen grains	Per cent Iodine Positive	Variety	No. Pollen grains	Per cent Iodine Positive	Variety	No. Pollen grains	Per cent Iodine Positive	Variety	No. Pollen grains	Per cent Iodine Positive
PR 26-14	930	69.9	POJ-2878	718	27.0	PR-334	500	47.0	POJ-36	750	0.0
PP-26-8	772	59.3	Al-32	506	30.2	PR-358	474	34.8	G-119	750	0.0
			PR-507	649	55.5	PR-422	849	56.5	POJ-2883	700	0.0
			US-875	577	52.4	PR-202	705	35.2	PR-723	435	14.2
			PR-702	732	50.0	Al-15	1408	0.59	Tuc-521	425	2.8
			Co-281	859	37.0	Tuc-450	556	5.8	POJ-2364	750	0.0
			PR-701	717	74.9	PR-547	1180	47.2	Tuc-491	500	0.0
			PR-208	421	74.6	Tuc-472	1294	11.2	POJ-2725	500	0.0
			PR-207	638	70.9	Tuc-454	1016	0.17	CP-807	850	0.0
			PR-367	547	32.0	PR-720	725	54.0	PR-440	783	11.7
			PR-26-187	735	45.0	Co-213	576	26.4	POJ-36M	700	0.0
			PR-338	613	44.0	POJ-2822	879	35.0	CH-64-21	700	0.0
						Ba-11569	1026	8.0	Merthi	700	0.0
									PR-807	700	0.0
Total	1702	65.1		7712	48.9		11188	17 7		9223	2.25
Maximum		69.9			74.9			56 5			24.2
Minimum		59.3			27.0			0 17			0.0

The 1931 data show a similar trend of the average per cent of positive reacting pollen grains to increase with the increase in intensity of the anther color. The range and therefore the variability is very high in both years.

If we may assume that arrows with 50 per cent fertility as indicated by the iodine test are worth using as parents then anything below medium in color should be only used after a microscopical examination with iodine has been made. Of course all varieties used as males should be checked up for pollen fertility by the iodine test sooner or later.

SUMMARY

1. It has been shown that within rather wide limits there is a positive relationship between pollen fertility as indicated by the iodine test and the degree of anther coloration in the sugar cane.

2. That pollen samples taken from dried flowers nine months after the fresh samples have been taken are similar in their iodine reaction has also been demonstrated.

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BACTERIAL WILT OF TOBACCO IN PUERTO RICO AND ITS INTERTRANSMISSION TO OTHER SOLANACEOUS HOSTS

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Although bacterial wilt of the Solanaceae has been repeatedly reported by various investigators from Puerto Rico, Henricksen (**2**), Stevenson (**9**), Stevenson and Rose (**8**), Smith (**7**), Thomas (**11**), López (**4**), Seaver and Chardon (**6**), Cook (**1**), and more recently by Nolla (**5**), attacking tomato, eggplant, pepper, potato and other plants*, the disease has never been found naturally in tobacco nor has been produced artificially by inoculation with supposedly pure cultures of *B. solanacearum* E. F. S. from other hosts. Cook (l.c.) suspected the pathogene to be a different one when his cross inoculations with the organism from eggplant succeeded on tomatoes and peppers but failed on tobacco. Nolla (l.c.) in a very comprehensive study of the disease concluded that the Puerto Rico organism, although morphologically similar to *B. solanacearum* E. F. S. was a strain incapable of infecting tobacco. He suggested, however, the possibility of all varieties of tobacco on the island being resistant to the organism.

The present investigation was initiated with the purpose of ascertaining why tobacco was not attacked by the Puerto Rican strain and, if so, the relationship between the tobacco organism and the one attacking other Solanaceous hosts of economic importance, viz., tomato, eggplant, pepper and potato. With the introduction of new tobacco varieties as a means of improving our standard types and, more recently, with the expansion of the vegetable growing industry into what was formerly tobacco land, the importance of elucidating this point not only has a purely scientific value but also a decided economic importance.

History

The writer found what was apparently the first observed case of bacterial wilt on tobacco in Puerto Rico in the summer of 1931, among two of our standard varieties, Ceniza and Utuado, growing in a field that for the last 10 years has been planted with sugar cane and, more recently, with strawberries. The plants were about 18

* Zinias (*Crassina elegans* (Jacq.) Kuntze); *Solanum torvum* L.; *Solanum caribaeum* Dunal. Undoubtedly many other plants are attacked under our conditions.

inches high and growing rapidly. Two of the Utuado plants were carefully pulled and their root systems washed. No symptoms of fungus attack was evident and the roots, except for the end of the main branch, appeared to be healthy. After stripping the plants of their leaves, the greater part of the stem was cut off until almost a solid core of woody tissue near the base of the stalk was left. The roots were then set in a beaker with distilled water in such a way as to leave the stub above the surface. In a few minutes, a slimy, brownish exudation appeared on the cut surfaces. A microscopic examination of the exudate, revealed the presence of enormous numbers of motile, rod shape organisms, similar in morphology to *B. solanacearum* E. F. S.

Agar plates from sterile water suspensions of the ooze failed to develop colonies after five days, but streaks made directly from the exudate made good growth. From these slants, agar plates were poured which in 48 hours developed watery, translucent colonies. Sub-cultures were then made from these colonies and in eight days developed the typical brown pigment characteristic of this organism.

Morphologic Symptoms.

In the Field.—The symptoms of the disease when occurring naturally in the field are typical and distinct. The first indication is the sudden wilting of one or more of the youngest leaves. When only one leaf wilts it is usually the third or fourth youngest from the top. The leaves wilt either totally or partially; when partially, the tip or only the area of the blade at either side of the midrib withers; when the whole leaf wilts, it droops, so that only the ventral side of the leaf is visible. The wilting and drooping of a single leaf near the top is an unmistakable early symptom of the disease. These early manifestations of infection are usually evident late in the morning hours when a bright day follows previous heavy rains.

If the variety is resistant to the malady, the symptoms progress no further and in a week or two the plant completely recovers. Because of the fact that all of our standard varieties are highly resistant to infection, as will be demostrated further on, this may explain the reason why the disease has been previously overlooked.

In case of susceptible varieties, successive wilting of the other leaves follows, usually the older ones, and the normal growth of the plant is checked so that adjacent healthy plants shortly outgrow them. Wilting is not uniform along the plant, but usually one side is more wilted than the other or not wilted at all. Wilted areas may show a slight yellowish discoloration, but a marked chlorosis is not

typical. The leaves finally rot, in some cases, only the stalk with a few stripped midribs remaining. If hot dry weather follows the initial symptoms, the leaves are irregularly scalded, in a short time dry up, become brittle and desintegrate. With moist weather, the leaves gradually turn yellow, then brown and finally rot without becoming brittle. In advanced stages, the stem blackens, becomes hollow and shrivels up.

When the roots of diseased plants are examined dark grayish to black, slightly sunken blotches are often present in the main branches. Usually the rootlets arising from these branches are dead and their cortex is easily removed. When cross sections of the affected roots are made, droplets of a slimy ooze appear on the cut surfaces. For diagnostic purposes this is the critical evidence of infection by bacterial wilt.

Under Puerto Rican conditions, the writer had no difficulty in differentiating between fungus wilt as produced by *Rhizoctonia solani* Kühn, *Phytophthora parasitica* var. *nicotianae* Tucker, and bacterial wilt, as soon as the early symptoms of both types of infection are evident. In the former cases, the wilting is sudden and general, that is, practically all the leaves wither and droop simultaneously and a marked chlorosis is immediately noticeable. Wilted plants do not recover from day to day with the advent of moist weather and cloudy mornings as plants attacked by bacterial wilt do in the early stages. So clear cut is the difference that the writer never failed to obtain critical signs of bacterial wilt on plants marked as such as soon as the first symptoms were observed.

Symptoms were observed at all stages of growth from three weeks after setting plants in field.

On Inoculated Plants.—The symptoms manifested by inoculated plants in pots were identical in every respect to those observed under field conditions, especially so, in the early stages. Inoculated plants, however, seldom were completely destroyed; partial or complete recovery being oftener the case. In many instances, recovered plants would exudate the slimy ooze even when cut 10 inches above the point of inoculation.

Brown and sunken longitudinal streaks along the stem were often produced by inoculated plants, but this symptom was never observed in the field. When these areas are punctured, exudation of ooze follows.

Dwarfing and undeveloped root systems are also pronounced symptoms of inoculated plants.

Histologic Symptoms

Bacterial wilt is primarily a disease of the vascular tissues of the plant. In tobacco as well as in other suscepts studied, however, the pith is nearly always affected and in many cases also the cortex.

Tranverse sections of affected parts of the roots or stems shows the vessels completely occluded with the bacterium. There is a pronounced discoloration of the wood which varies in color from reddish brown to dark brown. Shortly after the cut surfaces are exposed a sticky exudate oozes out of the vessels in tiny droplets which rapidly enlarge and coalesce. Both the consistency and the color of this ooze varies with individual cases, in some instances being watery while in other it is very thick. The color varies from pearl white in plants recently infected to a very dark brown in advanced cases, although individual droplets from the same stem may differ among themselves as to color.

The pith is nearly always affected and when the attack is severe it is rapidly disorganized. As a result the stem collapses, forming indentations and twisting around. It is also stained brown, but to a lesser degree than the woody tissues. In some cases the bacterium invades the cortex forming necrotic areas which enlarge with the advance of the infection. The woody tissues, although becoming functionless, are not disorganized until invaded by secondary saprophytes.

Etiology.

Morphological, cultural and pathogenecity studies establishes the organism responsible for bacterial wilt of tobacco in Puerto Rico as identical to *Bacterium solanacearum* E. F. S. (*Phytomonas solanacearum* (E. F. S.) Com. S. A. B.)

The pathogene is extensively disseminated throughout the island and is responsible for a similar disease in other Solanaceous hosts among which tomato, eggplant, pepper, and potato are the most important.

Morphological and Cultural Characteristics.

The following characteristics are typical for the organism under discussion:

Rods, 0.5 μ in width, varying in length from 1.0 μ to 1.5 μ; motile by a single polar flagelum (two preparations stained by Cesares—Gil method) which is 3 or 4 times longer than the cell; motility is best observed in hanging drops of fresh ooze or in broth cultures 48 hours old at room temperature (25° C. to 30 ° C.). The cells stain well

with ordinary anilin dyes but specially so with carbol fuchsin. In good preparations a more pronounced staining of the polar regions as well as a plain constriction at the center are evident.

Standard nutrient agar plates begin to show surface colonies in from one to two days; in general these are small, circular and slightly raised, transparent at first, resembling tiny drops of water on the surface of the agar, changing to whitish when seen by reflected light in one to two days, but brownish by transmitted light and producing a brown pigmentation which varies in intensity from very light to dark brown after a week old, and diffuses into the agar. Sub-surface colonies are variously shaped, usually elliptical.

Nutrient agar and litmus lactose agar slants show a filiform type of growth; the agar in the latter case acquiring a more intense blue color with age particularly near the region of growth. The streaks are semi-liquid during the first few days and run into the condensation water if kept upright.

Gelatin stabs show no liquifaction when two weeks old.

Milk is cleared without precipitation of the casein and the medium acquires a bright brownish hue. Litmus milk becomes more intense blue with age without precipitating.

Broth cultures become clouded in 24 hours when a recently isolated culture is used; old cultures require a longer time for clouding the medium. In a few days a white precipitate is deposited at the bottom of the tube and the liquid becomes intensely clouded, with or without the formation of a very slight pelicle. As the cultures become old, the supernatant liquid becomes clear and develops a color which varies from amber to dark brown.

Growth on potato slants is at first watery, spreading, whitish or yellowish in color, later turning brown and the water becoming heavily clouded.

On Dunham's solution growth is similar to that of broth cultures. No growth has been observed on Cohn's solution.

No gas or acid is produced from saccharose, dextrose, glucose, maltose, lactose or mannit broths.

Nitrates are not reduced; indole is not produced.

Spores have not been observed. The organism is aerobic and gram negative.

The length of time for which the organism remains viable in pure cultures is variable; good growth has been obtained from broth cultures three months old. Liquid cultures remain viable for a longer period than cultures on solid media.

The above description of cultural and morphological characters corresponds to the ones given by Smith (l.c.), Stanford and Wolf (**10**), Nolla (l.c.) and other investigators elsewhere for *B. solanacearum* E. F. S.

Inoculations.

Methods and Inoculum.—The irregular behavior of plants inoculated with *B. solanacearum* E. F. S., was first noted by Smith (l.c.) and confirmed by practically all investigators on the subject since then. Similar difficulties were encountered by the writer. These were augmented by the fact that the organism rapidly or immediately loses its pathogenic ability when artificially cultured.

In an effort to obviate these difficulties, several methods were tried in the early stages of these studies, two of which were finally adopted in conducting inoculations and cross-inoculations with marked success.

Both the aerial and the underground parts of the suscepts were inoculated. Except in two or three instances, all inoculations performed above ground failed. They even failed when conditions for the development of the organism at the point of inoculation were provided. Identical inoculum, when used simultaneously underground, on plants grown alike, would reproduce the symptoms of the disease.

Sub-cultures from poured plates; broth cultures made directly from ooze or from sub-cultures; streaks made directly from ooze; colonies from poured plates; sub-cultures on potato slants; ooze directly from diseased plants, and pieces of diseased wood were used as sources of inoculum. Except when ooze or pieces of wood were used, the age of each of the various cultures employed varied in from 1 to 7 days. Pieces of wood were invariably used the same day and ooze was used when not more than 48 hours old.

Of these, agar streaks made directly from ooze, pieces of wood and pure ooze were the most successful sources of inoculum; the last two mentioned giving very consistent results. Nolla (l.c.), pointed out that inoculations with ooze scarcely ever failed.

Symptoms produced by sub-culture inoculations no matter on which medium grown were usually of a localized nature; there is a slight brownish discoloration following the vascular bundles for a short distance below and above the point of inoculation or the pith was sometimes affected. Critical symptoms, however, were rarely, if ever, obtained.

In performing most of the inoculations upon which the conclusions arrived at in this paper are based, the usual procedure was to inoculate young, rapidly growing plants in 8-inch pots in sterilized soil, about one inch below the surface of the ground, either with ooze or with pieces of diseased wood from the same or other suscepts studied. The necessary ooze was obtained from roots and stems of recently wilted plants in the field. The soil around the stem near the surface of the ground was carefully removed and the stem washed with distilled water at the desired place. A slight injury with the end of a sharp scapel so as to pierce the woody cylinder was made and the ooze inserted at that point. The soil was then replaced and the plants watered once or twice a day until discarded. Checks were similarly treated, except that no inoculum was provided.

When pieces of diseased wood were used, thin slices of the material were cut with a sterile razor in such a way that one side of the section was thicker than the other, and kept in sterile water until used. With a sharp scapel, a longitudinal cut was made after proceeding as above. The end of the scapel was not removed until, with a pair of tweezers, the slip of wood, thinner edge first, was inserted into the cut. The whole scheme is in the nature of an underground graft.

These two methods were equally successful, but because of the large amount of ooze required when making extensive inoculations, the latter was much more convenient.

Pathogenicity.—Tobacco plants inoculated as above from naturally wilted plants developed typical wilt symptoms in from 4 to 10 days. When resistant varieties were used recovery slowly followed these early symptoms; when susceptible varieties were inoculated, the symptoms usually terminated in the death of the plants.

Broth cultures of the inoculum were plated when two days old and sub-cultures made. Soon after the symptoms on inoculated plants were well defined, the plants were pulled, washed and examined for the critical sign of infection: exudation of ooze for some distance above or below the point of inoculation. Sub-cultures of this ooze made as above were then compared with the original ones. In every case, they were found to be morphologically and physiologically identical.

Agar plates from broth cultures of the ooze nearly always yielded a single type of colony with slight or no contaminations. This is particularly the case when fresh ooze from recently wilted plants is collected as far up in the stem as possible. Parallel inoculations with these typical colonies with few exceptions failed, while those made

with ooze were successful. This points to the rapidity with which the organism losses its infective powers. Sometimes abundant fungus contaminations (*Fusarium* sp. and *Actinomyces* sp.) would appear in the plates. In these cases, the results obtained from ooze or wood inoculations were not considered.

In all inoculation work done, an average of two checks for every 10 plants treated were carried. They always failed to show the disease.

Intertransmission.

Nolla (l.c.) has shown that *B. solanacearum* E. F. S., as occurs in Puerto Rico, is intertransmissible to tomato, eggplant, pepper and potato. In an effort to establish the pathogenic relationship between the tobacco organism and these hosts, over 500 inoculations were made, more than one-half of which were successful. The routine procedure was to determine first the pathogenicity of the ooze from each suscept on itself and then to make direct and reciprocal inoculations between each of the five species under study.

Sufficient positive reactions were obtained in each case to warrant the conclusion that the organism responsible for bacterial wilt of tobacco in Puerto Rico is equally pathogenic to the other hosts under consideration and they, in turn, are equally pathogenic not only among themselves but also to tobacco.

Varietal Susceptibility.

Through the courtesy of Dr. R. F. Poole, of the North Carolina State College of Agriculture, the writer received seed of three flue cured varieties of tobacco: Cash, White Stem Oronoco and Adcock, known to be susceptible to bacterial (Granville) wilt. When tested, the Adcock seed failed to germinate.

In the Summer of 1931, 200 plants of each of the Cash and Oronoco varieties were grown in a field known to be heavily infested with the organism, as demonstrated by the high incidence of infection when either tomatoes or susceptible eggplants were grown on it. They were planted alternately in 10 rows, 3 ft. apart, 40 plants to a row. Hot, rainy weather followed for weeks after transplanting to the field. A perfect stand was secured by continued replantings. Notes on incidence of wilt were taken once a week, as soon as the first symptoms * were observed. The results are given in table 1.

* Before finally recording any plants showing symptoms as positive, a critical examination for bacterial exudate was made.

TABLE I

INCIDENCE OF WILT ON TWO IMPORTED TOBACCO VARIETIES

Variety	Population	Healthy	Wilted	% Wilted
Cash	200	87	113	56.5
White Stem Oronoco	200	53	147	73.5

The results demonstrated that these varieties are highly susceptible to the disease under favorable conditions for infection.

A more extensive trial was conducted in the same field early in the Spring of 1932. Besides the above mentioned types, our three most popular varieties: Virginia, Ceniza and Utuado, and a vigorous variety brought from Colombia in 1929 by Dr. J. A. B. Nolla, were included in the test. The same plan of planting as explained in the previous trial was followed. The weather was cool and dry at the time of planting and remained so for two or three weeks after. In consequence, the plants failed to grow rapidly and the symptoms of bacterial wilt appeared very late, even at flowering time with the early varieties. Symptoms of fungus wilt, however, showed much earlier and to such an unexpected extent that it became obvious that this factor had to be taken into consideration in analyzing the results. These are given in table 2.

TABLE II

INCIDENCE OF FUNGUS AND BACTERIAL WILT ON LOCAL AND IMPORTED TOBACCO VARIETIES

Variety	Population	Plants infected with fungus wilt *	Percent infected with fungus wilt	Plants infected with bacterial wilt	Percent infected with bacterial wilt from total No. of plants	Percent infected with bacterial wilt from healthy plants only **
Virginia	180	39	21.66	15	8.33	10.63
Utuado	201	22	10.95	18	8.99	10.05
Ceniza	202	65	32.12	13	6.43	9.48
Cash	201	98	48.75	23	11.44	22.33
Oronoco	204	63	30.88	46	22.54	32.62
Ambalema	212	33	15.56	30	14.15	16.75

* *Rhizoctonia solani* Khün and *Phytophthora parasitica* var. *nicotianae* Tucker.

** The per cent of bacterial wilt from healthy plants only, i.e., from those remaining after deducting the ones infected with fungus wilt.

The writer is inclined to consider the percentage obtained in the last column as a more accurate estimate of the true incidence of infection for each variety under the conditions of the experiment because the early invasion of plants attacked with fungus pathogenes prevented the infection with *B. solanacearum,* which, as stated, developed much later in this particular trial. Furthermore, not a single plant attacked with fungus wilt was found to be also infected

with bacterial wilt, when such a condition ought to have been possible had every plant had an equal chance of infection with the bacterial pathogene.

The results show that tobacco varieties exhibit a wide range of susceptibility to the disease and that, even under conditions of high soil infestation, our standard varieties are highly resistant to the disease. The Ambalema is less so and the North Carolina varieties very susceptible. Furthermore, our standard varieties, although exhibiting unmistakable signs and symptoms of the malady, were able in practically every case, to recover rapidly without any appreciable loss and the same is true, although to a lesser extend, of the Ambalema. Both the Cash and White Stem Oronoco varieties presented not only more severe symptoms of a progressive nature, but in the majority of cases every diseased plant was an actual loss.

With repect to the two last-mentioned varieties, the results are in harmony with those presented in table 1. The fact is also brought out that the disease is much more severe during hot, rainy weather than during the cool, semi-dry season. Because tobacco is grown in Puerto Rico under the last mentioned conditions another reason for the rare occurrence of the disease in commercial plantings in presented.

Discussion.

The systematic position of the organism responsible for bacterial wilt of tomato, eggplant, pepper and potato in Puerto Rico has been repeatedly questioned, because although morphologically and physiologically similar to *B. solanacearum* E. F. S., it has been found unable to infect tobacco under natural conditions or when artificially inoculated. In the Summer of 1931, the writer found a natural case of wilt in tobacco exhibiting symptoms very similar to the so-called Granville Wilt in the United States. Cultural studies of the organism involved identified it as similar to the ones isolated from other known suscept. Extensive direct and cross-inoculations with the exudate characteristic of the disease established its pathogenecity and intertransmission. Agar plates of this exudate yielded either pure cultures of an organism morphologically and physiologically identical with *B. solanacearum* E. F. S. or mixed colonies from which the organism was readily isolated. In the light of these results and of previous studies of Smith (l.c.) and Nolla (l.c.) when studying Puerto Rican material, it is concluded that *B. solanacearum* as occurs in Puerto Rico is identical to *B. solanacearum* as described by Dr. Edwin F. Smith.

The life history of the organism and suitable control measures were not included as a part of these studies because these phases of the problem have been adequately treated by other investigators here and elsewhere. The writer is of the opinion, however, that invasion of tobacco under our conditions very seldom, if ever, takes place through the aerial parts of the plant, but through the underground parts. In hundreds of wilted plants examined, the advance of the infection could always be traced from the roots towards the stem and never in the opposite direction. Aerial inoculations on peppers, however, have been successful.

Rotation of crops as a mean of control seems to have very limited, if any, possibilities. In fact, the first case of tobacco wilt was found in a field which has been growing sugar cane for many years. A field test of four varieties of tomatoes in a field not planted with any Solanaceous crop for at least 15 years, was a complete failure because more than 40 per cent of the plants were killed by the disease.

Breeding for resistance is, undoubtedly, the most promising control measure. Nolla (l.c.) found some varieties of eggplant and pepper highly resistant to the malady. Under our conditions the variety of potato Red Bliss Triumph is very susceptible while the Irish Cobbler, when grown under similar conditions, is very resistant. Tobacco varieties have shown a wide range of resistance. It is only in tomatoes that a resistant variety has not been found.

ACKNOWLEDGMENT.

The writer wishes to express his thanks to Dr. Melville T. Cook, Chief of the Division of Phytopathology, for his unfailing encouragement during the course of this investigation and for the revision of the manuscript.

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Explanation of Plates.

Plate I.—Two nutrient agar plates using different dilutions from a broth culture made directly from tobacco ooze. Only typical colonies of *B. solanacearum* developed. This ooze was used to inoculate plants shown on plate II.

Plate II.—*Upper:* Plants of the "Ceniza" variety artificially inoculated with bacterial ooze from wilted tobacco plants, photographed 10 days after the inoculation. Plants at left and right are showing typical symptoms. Middle plant, check.

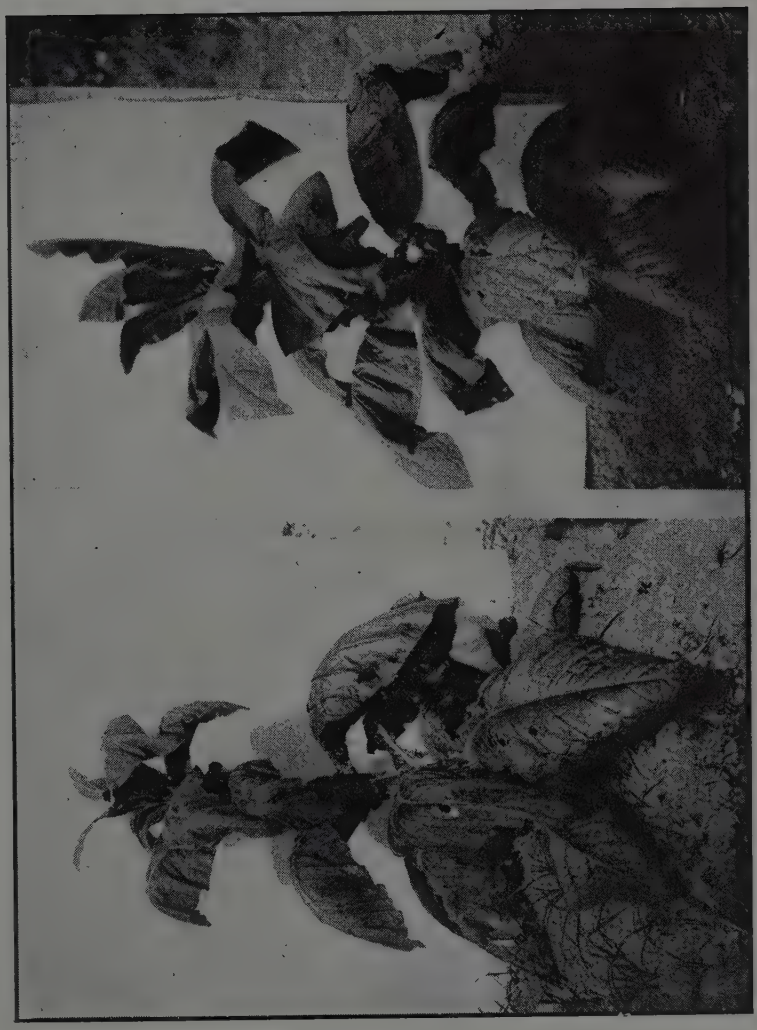
Lower: Same as above using plants of "Utuado" variety.

Plate III.—At left naturally wilted plant and at right healthy plant of the imported variety "Cash".

PLATE I.

PLATE II.

PLATE III.



CONCERNING THE ORIGIN OF THE WHITE QUARTZ SANDS OF NORTHERN PUERTO RICO

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There are numerous deposits of white quartz sands of varying depths which are distributed in belts and spots from a few miles southeast of San Juan to a point about 4 miles southeast of Quebradillas. The largest deposits occur between San Juan and Manatí. Nearly every scientist who has observed these sand deposits has conjectured as to their origin and several have offered tentative theories. Most writers have merely mentioned them without attempting to offer an explanation of how they were accumulated.

The writers had the opportunity to study these white sands in great detail while making a soil survey of the districts in which they occur in abundance. We herewith submit our findings and we believe that we have been able to explain, at least in part, the methods and forces which have caused the accumulation of these deposits.

For the benefit of those unfamiliar with these sands a brief description of them and their environment is in order. The "white sand" deposits consist of white or gray quartz sands which vary in depth from a "smear" of a few inches to dune-like deposits 15 feet or more in thickness.[2] Usually the surface six or eight inches of these sandy areas will be light gray colored while the subsoil will be nearly white. In many places the water table is reached at from 20 to 50 or more inches depth. In these places the white sands are

[1] The authors are indebted to the Director of the Insular Experiment Station, Mr. F. A. López-Domínguez and assistants Messrs. Jorge Landrón and David Rodríguez for their helpful cooperation in the prosecution of the soil survey of the north coast which furnished the basis for much of the contents of this paper. We are also greatly indebted to Dr. N. L. Britton of the New York Botannical Garden, Chancellor Carlos E. Chardón of the University of Puerto Rico, and Dr. H. A. Meyerhoff of Smith College for valuable suggestions. Dr. C. F. Marbut, Chief, and Mr. Mark Baldwin, Inspector, of the Bureau of Chemistry and Soils furnished valuable criticism and suggestions which have greatly added to the value of the paper. Messrs. Ray C. Roberts and A. T. Sweet, of the U. S. Bureau of Chemistry and Soils; and Messrs. Juan Zalduondo and Fernando A. Villamil of the Insular Experiment Station furnished soil maps of the San Juan district which were of great use in studying the distribution of white sands in that region.

[2] Cook and Gleason (3) in their "Ecological Survey of Puerto Rico", published in the July, 1928, issue of the Journal of the Department of Agriculture of Porto Rico, describe the white sands in part as follows: "The soil is composed of white, *calcareous* (italics ours) sands of unknown depth." As a matter of fact these white sands are practically pure quartz and their acid reaction demonstrates that they are distinctly non-calcareous. Possibly the sands were confused with nearby shell sands which are highly calcareous. It is commonly believed among the farmers of the northern coastal region that these sands consist of limestone grains.

underlain by a heavy, columnar and highly acid clay which is exceedingly difficult to penetrate with digging tools. This clay is usually gray in color with streaks and blotches of bright red or yellow or both. The thickness of the clay varies and is known to be more than 15 feet deep in places. The cracks and root holes are usually lined with white leached clay (probably kaolin). The sand, where it contacts the clay, is usually stained dark brown or dark gray and is often cemented into a "hardpan". Superficial observation would lead one to believe that this cementing material consists of iron oxides (limonite) but if the "hardpan" is ignited the dark color disappears and leaves a white or sometimes a pale yellow sand. It is evident, therefore, that the cement is of organic material. In a few places it was observed that the hardpan layer was partly of iron and partly of organic material. When the hardpan from these latter places is ignited the organic part of the cement burns out and the residue, owing to the effect of iron oxide, assumes a light red or or pinkish color.

The underlying clay material, when it is exposed in a ditch bank or road cut, exhibits a strong tendency to form vertical columns. These columns break up into well defined prisms of varying sizes which are very hard when dry and exceedingly stiff and resistant to pressure when moist. In the wet condition a good degree of plasticity develops.

There are many places where the white sands lie on knolls or on gently sloping hillsides and a few places where the slope is quite steep. At first sight one would expect that the natural drainage would be good or even excessive in these places. This is frequently true but in many apparently well drained areas there is a heavy, tight clay like that described above which holds up the descending waters after rains and causes the lower layer of white sands to be wet much of the time. In these places, just as in those described in the foregoing an organic hardpan forms. The places where the white sands have good subdrainage do not have well developed organic hardpans and in some places even dark organic stains are lacking.

Where the white sands are deep they tend to blow up into low dunes and to spread out into layers of varying thickness over adjacent soils. In places where the latter has occurred one does not, of course, find the normal profile development.

All of the sands observed occur within the belt of land where the Tertiary limestone forms the bedrock. Britton (1), Chardón and others have suggested that these sands may be the residuum left

from the weathering of these limestones. There is much evidence to support this hypothesis. The Tertiary limestones have been weathered in a manner peculiar to the tropical regions. Except for small areas where the large rivers have cut their way through from the interior of the island, surface alluvial erosion is negligible. Underground streams remove most of the water which falls on the Tertiary limestones and these streams are fed by water which seeps down through the porous limestone and sinkholes. Differential solution of the limestones has led to the formation of myriads of "solution valleys" and intervening *"mogotes", "pepino"* (cucumber), or "haystack" hills. These "haystack" hills are closely spaced in places and in other places stand out in isolated groups or in rows in the larger open valleys.

Where the white sands occur in "solution valleys" which are entirely surrounded by high hills there is no other probable source for them than the limestone itself. There seems to be little if any doubt that this is the case. The writers, with this in mind, made a large number of observations to see whether the limestones contained quartz sand in sufficient quantities to account, not only for the white sands but also for the sands which occur in the valley soils which are red, brown, or yellow in color. It was found that there are many layers of limestone which contain more or less sand and there are a few thin interstratified layers of clays and sands which contain little or no lime. Dr. Britton (1) once observed sandy layers in the limestones near San Juan and our more extensive observations have confirmed his findings. Places where these sandy layers may be easily observed are in the vicinity of Almirante; six miles southwest of Arecibo on the Lares road; 4 and ½ miles southeast of Hatillo; and on the Camuy River trail 5 and ¼ miles southeast of Camuy, 300 yards before the river is reached. In the latter place there is a 3 or 4 foot thickness of limestone which, perhaps, contains as much as 30 per cent of quartz sands. A sample of decayed limestone from 4 and ¼ miles southeast of Hatillo was examined by Fry of the U. S. Bureau of Chemistry and Soils and he estimated that it contained 25 per cent of quartz sand. The sandiest soils of limestone derivation and the areas of white sand were observed in the localities where it was definitely determined that the limestones contained appreciable quantities of sand. This is by far the most plausible explanation of the origin of the white (and other) sands of the localities which are *remote from the seacoast.* The dissolving of great thickness of these limestones would readily account for the accumulation of sands in the "solution valleys". It might be observed in passing

that the sandy limestones occur in the transition zone between the youngest of the Tertiary beds and the second youngest. These different divisions have been described by Hubbard (**5**), Meyerhoff (**9**) and others. Meyerhoff [3] suggests the possibility of artesian springs bringing up the sands from underground, but we observed no place where this would seem to be a plausible explanation.

The largest beds of white sands occur fairly near the seacoast at distances varying from ½ mile to 2 and ½ miles. The limestone hills between them and the ocean are often quite low and rounded and in many places it seems quite possible that sands from the beaches may have been blown over the hills by the prevailing northeast trade winds. One of the largest deposits occurs 1 and ⅕ miles southwest of Arecibo. In this place the sands occur intermittently over a large U-shaped area the two arms of which extend in a west-southwest direction. Over most of this area the sands lie on a nearly common level and comprise flattish bench-like deposits. Numerous deep sinkholes indent this flattish area and it is surrounded by low-lying, rounded limestone hills. A few of the white sands in this district are on the tops of low rounded knolls and above the average level of the main body. The sands of the northern arm and eastern end of this area grade into acid brown sands which are frequently underlain by heavy clay subsoils similar to those under the white sands. Several large areas of the brown sands have a sandy iron hardpan layer between the soil proper and the subsoil. These acid brown sands, in turn, grade into alkaline brown quartz sandy soils as the coast is approached. These latter sands are without doubt largely derived from the disintegration of the San Juan consolidated sand dunes the sands of which are being broken apart by the waves on the seacoast and spread inland by the trade winds. It should be remarked for the benefit of those not familiar with the San Juan sand dunes that they were originally piled up by the trade winds on a bar near the shore and have subsequently been cemented by lime. This cement was very probably formed by a deposition of lime which resulted from the evaporation of sea spray. Some of the lime may also have come from the solution and redeposition of the lime of sea shell fragments. Probably the acid brown sands which are farther inland than the alkaline sands were largely derived from the sands which have spread inland from the coast through the agency of wind. They are acid because the leaching of the lime in them

[3] In 1931–32, Dr. H. A. Meyerhoff of Smith College, delivered a series of lectures at the University of Puerto Rico. These lectures are to appear in book form at an early date and their author very kindly permitted us to read the manuscript.

has exceeded the rate at which the limy material from the coastal sands has been supplied. At the present time there is very little transportation of material taking place because of the fact that grasses and bushes are holding the sand in place.

It may be readily surmised from the above that at least a part of the white sands near Arecibo have been derived from brown sands which have been blown inland from the coast. The present pale gray or white color is due to excessive acid leaching by ordinary soil forming processes. These processes will be discussed later in greater detail.

Another possible explanation of the presence of a large body of white and gray sands near Arecibo is that there may have been an old lake, swamp or estuary in this locality and the sands may have been deposited along its shores or on the bottom. A deposit of white sands now borders Laguna Tortuguero farther to the east. The great thickness of heavy mottled clay under the white sands lends credence to this theory. Another evidence to lend support to the theory of an old estuarine or lake deposition is the fact that it is well known that the coast line between Arecibo and Aguadilla has been much lower in the past. High wave-cut terraces are to be discussed in Meyerhoff's "Geology of the Arecibo District" so we shall not discuss them further here.

In many places between Manatí and San Juan the deposits of sand are very deep and in many of these places there is unquestionable evidence that they have been reworked by the wind since original deposition.

Between San Juan and Carolina there are deposits of white sands surrounding swampy and mucky areas where the evidence seems to be in favor of lagoon shore deposition. Granting the idea of some of the sands having been old beaches we still may be permitted to wonder from whence the sands were originally derived. We may still logically suppose that a fair share of them came from the dissolution of the Tertiary limestones and perhaps a part of them from the weathering of the nearby San Juan formation. If we must go back to first beginnings the quartz grains doubtless came from the weathering of granites and other siliceous rocks of the "oldlands" of the interior. The rivers carried the sands down and the waves and currents spread them out over the Tertiary sea when the limestone strata were being built up.

Up to the present point in our discussion we have devoted our remarks almost entirely to the explanation of the different probable sources of the white sands with scarcely any mention of why they

are *white* instead of brown, yellow or red like the other sands with which they are closely associated. The answer to the latter question is one which may be best referred to soil science. Soils quite similar to the white sands of Puerto Rico occur abundantly in the southeastern coastal plains of the United States. They are especially abundant near the Atlantic seacoast in Georgia and Florida but occur in scattered localities somewhat farther north than Lakewood, New Jersey. The areas of white sands in Puerto Rico which have a high water table are very much like the *León* and related sands of the coastal plains of Georgia and Florida, while the deeper sands are much like the *St. Lucie* soils of Florida. The shallower types, which are well drained, resemble the *Lakewood* sands which are distributed from New Jersey well into the southern states. Hearn (**4**) estimates that there is a total area of about 4 or 5 million acres of the *León* sand alone. This is about twice the total area of Puerto Rico. The *Lakewood* and *St. Lucie* soils in their turn occupy a tremendous additional area. Cobb (**2**) observed similar sands in France and Bennett found a few areas of *León* sands in Nicaragua. It should be plainly understood at this point that there are several minor points of difference between the different types of white sands in Puerto Rico and the similar types on the United States mainland. We cannot, therefore, call them by the same names. Soils of the *León* series are characterized by a dark gray, strongly acid, sandy surface about 4 inches thick, about 18 inches of white quartz sand and a 10 inch organic hardpan just above the water table which occurs at about 32 inches from the surface. Beneath the hardpan there is normally a loose wet yellowish sand to considerable depths. In some places, however, the hardpan is underlain by a stiff mottled clay just like the clay layer underlying much of the Puerto Rico white sands. The deeper white sand deposits of Puerto Rico more closely resemble the *St. Lucie* sand of Florida which consists mainly of a loose, white quartz sand to great depths. This sand also has an organic hardpan or at least streaks of dark organic matter at or near the water table level if the latter occurs within the sand itself. It may be easily seen from the foregoing that white sands similar to the sands of Puerto Rico are very well known indeed in other parts of the world.

The general processes by which soils of this type are formed are well known. Marbut (**6**) speaks of the *León* sands as "ground water podzols" and of the *Lakewood* sands as true podzols. Typical podzols or "ashy gray" soils are formed in well drained areas under a humid climate and usually under a conifer forest cover. They are characterized by a surface mulch of semi-decayed organic debris such

as pine needles, leaves, rotten wood, etc.; an ashy gray or nearly white "leached horizon"; a B-horizon or accumulated iron, clay and organic matter and the underlying parent rock. "Ground water podzols", such as the poorly subdrained types of white sands in Puerto Rico, usually occur only where the parent materials are originally very sandy and where the water table is relatively high, or in other words, where subdrainage is very poor. Until quite recently it has been believed by most soil scientists that true podzols can be formed only in a cool temperate region but Marbut (6) has shown that the *Lakewood* sand is a true podzol and it extends well into the warm temperate regions of the south. It is significant, however, that only the very leachy sandy soils have thus far been proved to form typical podzols outside of cool temperate regions. True podzols derived from heavier materials, have been thought to be confined largely, if not entirely, to humid cool temperate regions, either in high latitudes or at high altitudes in low latitudes. Abundant evidence of podzolization in many parts of Puerto Rico from sea level to 3,000 or more feet above the sea, have proved that the process is active here and it is possible that small areas of true podzols from heavier materials than sands may be discovered. A bit of evidence along this line will be discussed later in this paper.

Probably much more than half of the white sands of Puerto Rico are "ground water podzols". Hearn (4) in a paper read before the eleventh annual meeting of the American Soil Survey Association, November, 1930, has given a good review of the formation of the *León* type of soil profile, which so closely resembles the ground water podzols of Puerto Rico. He laid special emphasis on the formation of the organic hardpan, which, before analyses were made, was thought to consist of oxides of iron. Briefly, the original material is very sandy and contains only very small percentages of silts and clays. The silts and clays are removed by the downward percolation of meteoric waters. This process is known as "eluviation" and it is aided and hastened by the colloidal organic acids produced by the decay of plant remains. These acids act as solvents for colloidal iron stains which lend ordinary quartz sands a red, yellow or brown coloration, with the ultimate effect of bleaching the sands white. Colloidal organic matter is formed by the work of bacteria which cause the decay of dead roots and leaves of plants in the soil proper. Much of this material is precipitated at the level of ground water forming the organic hardpan. The mass of hardpan is greatly increased by the presence of plant roots which accumulate at the level of ground water. In the southeastern states one of the commonest

plants is the sawtooth palmetto and its roots have been observed to be concentrated in the hardpan. On some of the white sands of Puerto Rico the corozo palm is quite common and it is quite possible that its roots, as well as those of other plants, have contributed to the hardpan.

We may then offer the following suggestions as to the formation of the poorly drained white sands of Puerto Rico. First we start with a soil material which contains a very high to fairly high percentage of silica sands. This sandy soil will lie in a fairly flat position and must either contain an impervious layer beneath or must contain material which may later be used by the soil forming processes to cause conditions of poor drainage. Poor drainage may, of course, also be caused by a high water table which has been brought about by proximity to sea or lake level. There must be some vegetation to furnish organic material to be used by the soil in forming acids, and there must finally be a humid climate to furnish the necessary leaching waters.

In the case of the largest deposits of the sands the original material seems to have been derived partially as a residuum from dissolved slightly arenaceous limestones and partly a subaerial accumulation of sands which have been carried inland from the wave-shattered San Juan sandstone formation. There is some evidence that some of these sands are littoral deposits which have remained after a slight withdrawal of water of the sea and lagoons in recent geological times. It seems almost certain that these larger deposits of sandy materials were locally transported by wind or water or both and deposited on the gray clays of lowlands possibly formerly occupied by lagoons, estuaries or sinkhole ponds. This gray clay furnished the necessary conditions of poor drainage. Vegetation occupied the soil and the leaching of the minor amounts of silts and colloidal materials proceeded at a rapid rate. In many places, typically a short distance southwest of Arecibo, there is a regular transition from highly leached white sands, through gray-brown acid sands to alkaline sands, proceeding toward the seacoast. All of the white sands are far enough from the sea to be almost entirely unaffected by the spray from the breaking waves which are piled up by the trade winds. Soils in this district so affected are universally alkaline in reaction. In such a leaching process any soluble salts disappear first, then the less soluble calcium carbonate and finally, after the decaying organic matter lends an acid condition to the soil, the other soil pigments are dissolved and carried out by the ground water. The poor drainage causes the iron to be reduced to the fer-

rous state which makes it much more soluble. In places where the parent sands contain larger amounts of iron and alumina than normal these materials are mixed with the hardpan.

The above description of the formation of white sands covers a very large total area of these soils. Many places having apparent good drainage, if one were to judge by surface appearances, in reality have a fairly high water table which usually lies just above the heavy clay layer. It is probable that most or all of the sands of these places should be classed as ground water podzols. There are many other places, however, where subdrainage as well as surface drainage is sufficiently good to throw the white sands into the class of true podzols which form only under normally good drainage conditions. Until very recently it had been considered by most soil scientists that it is very improbable that true podzols would be found in tropical lowlands. Marbut [4] and Affanassief and others have found evidences of podzolization in the tropical lowlands and they have predicted the possibility of the existence of true podzols in this position. We are unaware of such podzols having actually been found in tropical lowlands until last year when the white sands of Puerto Rico were thoroughly studied in the field. From a morphological standpoint the well drained white sands which we shall briefly describe below are unquestionably true podzols in the same sense that the *Lakewood* sands of New Jersey are true podzols. We fully expect that chemical analyses will confirm the morphological identification.

If the process of true podzolization is to account for the formation of the well subdrained areas of white sands it would be reasonable to suppose that the same types of deposit might be formed from different materials with different thicknesses of the product and with a large number of gradations between the typical white sands and other soils with which they are associated. One type of such gradation has already been mentioned. In those deposits occurring well within the limestone hills and several miles distant from the seacoast one of the commonest associations of white sands is with a group of soils known provisionally as the *Vega Alta* series. This series of soils has grayish brown surface soils with compact but moderately well drained, coarsely mottled red, yellow and gray subsoils, the former two colors predominating. The heavier types of this series, such as the clay and clay loam are more brown than gray in the surface but the sandier types become grayer with the increase in the percentage of sand present. In many cases the soil surveyor is puzzled as to whether to group these grayer sandier types of soils with

the *Vega Alta* series or with the shallower types of the white sand group. With the graying of the surface horizon there is sometimes a tendency for the subsoil to become more poorly drained. This change in the drainage conditions seems to have been brought about by the eluviation-illuviation process. The clays and colloids have been eluviated from the surface by meteoric waters and deposited in the interstices of the subsoil forming a layer of illuviation. This process slows up drainage and may in many cases ultimately result in the formation of a temporary shallow water table at which an organic hardpan begins to form. This gives rise to the ultimate formation of the ground water podzol type of white sand. On the other hand there are many places where the subsoil retains sufficiently good drainage to take care of the meteoric waters. One such area lies some distance south of Sabana Hoyo far within the limestone hills in association with soils of the *Vega Alta* series. It has the grayish white surface and white upper subsoil but lacks the organic hardpan. The underlying clay is typical of the *Vega Alta* series of soils and is therefore well drained. The upper subsoil, as in the case of the *Vega Alta* soils, has accumulations of iron and alumina in addition to small amounts of colloidal organic matter. The area occurs on the top of a sharp knoll and is unquestionably a typical sandy podzol. There are several small areas like this one southwest of Arecibo and scattered elsewhere throughout the northern coastal region in association with ground water podzols. Gradations between true podzols and the sandier types of the red *Bayamón* and *Espinosa* soil series are quite common. These red soils also grade into the ground water podzols. The very deep areas of white sands usually are more or less piled up by the trade winds and since they are so loose and dry in their upper horizons it is frequently impossible to determine whether they have water in the lower horizons and whether they have developed organic hardpans. It is altogether probable that part of these deep areas belong to the true sandy podzols and part to the ground water podzols. From the standpoint of agriculture or of commercial use of the sands this problem has no bearing. It is a matter of purely scientific interest.

While we are discussing the sandy podzols it might be of interest to add a further word regarding podzolization in Puerto Rico. A very large total area of soils in the lowlands as well as in the highlands exhibit strong morphological evidences of this process. Many of these areas are of the heavier type of materials such as silts, sandy clays and perhaps clays in places. An extreme example of such soils very recently observed on a low hill near the new pier at Mayagüez

is a silt loam with most of the morphological characteristics of a true podzol. We can at least be safe in saying that it is a very strongly podzolized soil. Rainfall is about 80 inches per annum and natural drainage is good. A description in outline form follows. It should be noted that the land has been cleared so that the original leaf mould has been destroyed.

Horizon	Depth	Description
A_1	0″ — 4″	Light brownish gray silt loam when dry. Pale yellowish brown when wet. Medium granular structure.
A_2	4″ — 10″	When dry grayish white; when wet pale yellow floury silt loam. No evident structure.
B	10″ — 30″	Heavy reddish brown and yellowish brown clay containing many tuff and shale fragments. Very stiff when moist. All surfaces of cleavage planes are light gray and silty and gray silt follows root channels.
C	30″ down.	Loose subangular gravels of tuffs, shale and cherty fragments. Possibly an old terrace remnant or elevated beach line.

This area is very small but we believe it to be a significant evidence of the progress of podzolization at low elevations in the tropics. It is of interest to know that this highly podzolized soil occurs within two miles of the largest body of typical ferruginous laterite in Puerto Rico. A number of other places having very similar soils have been observed and it is hoped they may be discussed more fully in a later contribution. We return to the white sands after this short digression.

These white sands in their present position must be considered as very recent deposits from the standpoint of geology. They are certainly younger than the San Juan formation since in no place observed do the San Juan sandstones overlap them. Recent as they are geologically, they are quite old from the soils standpoint. The age of a soil is not measured by the number of years since the weathering forces first started working on its parent material but by the degree of leaching and eluviation which have taken place. An old soil is one in which leaching and eluviation are far advanced. In the case of sands this can take place in a much shorter time than with soils of heavier texture or with those which are high in lime. It is certain that these "old soils" (the white sands) are younger in years than many of the "young soils" of Puerto Rico many of which are so highly valued by the farmers.

It is interesting to notice that there are no white quartz sands west of the Río Guajataca, at least not in the north coastal belt. There are plenty of brown quartz sands which would theoretically be capable of weathering into the white variety but this weathering has not taken place. There is a good reason for this. The rainfall from Camuy to the northwestern corner of the island averages considerably less than 60 inches per annum. A rainfall of 55 inches in Puerto Rico is approximately the dividing line between a humid and a semi-arid climate. Such a rainfall in this part of the tropics might at least be designated as sub-humid. The formation of large areas of white quartz sand requires the leaching effects which can be produced only by a humid climate, hence the disappearing of these deposits in the northwestern part of the island.

A few miles southeast of Humacao large quantities of loose, fine quartz sands and gravels have been washed from nearby quartz-diorite hills and deposited on the sea level estuarine clays of the Río Candelero delta. These very recent deposits have already begun to show signs of leaching under the influence of a heavy rainfall and poor underdrainage. The sands and gravels are changing from brown and yellowish brown to a pale yellowish color. Incipient organic and iron deposits near the level of ground water prognosticate a future development of hardpan similar to that in some of the white sands we have been discussing. The entire island has not yet been covered in detail and it is reasonably possible that very small deposits of white or gray sands somewhat similar to those of the north coast will be found in the humid regions which have not been thoroughly explored.

SUMMARY

The origin of the large deposits of almost pure white quartz sands which occur within the area occupied by the Tertiary limestones of northern Puerto Rico have long been a source of puzzlement to geologists. The largest areas occur within a mile or so of the seacoast in association with Tertiary deposits but are unconformable with them. Many of them are found in association with the remnants of lagoons which were cut off from the sea by the San Juan formation. Some deposits are also in fairly close association with the latter formation in some places. Smaller areas occur well within the limestone hills.

Examinations of limestone outcrops and of residual soils within the limestone hills indicate that a large amount of sand originally came from the solution of layers of impure limestone which formerly

overlay the district. It is altogether probable that some of the sands have been blown inland from the broken up San Juan formation and later leached of their lime. There is some evidence to support the theory that some of these sands may have been left in or near their present position along the shore of former lagoons which have since been drained by a slight emergence of the coast. There is but little question but that the smaller deposits several miles inland and well within the limestone hills are the residuum left from the dissolution of the limestones.

The whiteness and purity of the sands are due to the soil forming process known as podzolization (acid leaching and eluviation) which in this case has taken place largely under conditions of high rainfall and poor subdrainage and to a less extent under well drained conditions. Some of the deeper deposits which are now well drained have been more or less piled up by the winds since they were bleached. We can therefore state with reasonable assurance that the quartz sands have come from the various sources above mentioned but that they are *white* because of a high degree of "podzolic" leaching which has affected them since they accumulated. Millions of acres of similar soils which have been carefully studied by soil scientists in the southeastern United States have furnished the evidence for this explanation of the origin of Puerto Rico's white sand deposits.

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Explanation of Plates

PLATE IV

Figure 1. Area of white sand southwest of Arecibo. Vegetation consists of second growth of icaco (*Chrysobalanus icaco* L.) and pajuil or cashew-nut (*Anacardium occidentale* L.) Young cocoanut trees grow very slowly on these infertile sands.

Figure 2. Upper part of profile of white sand. Grayish surface soil slumped into pit at left center. White horizon shows plainly just under plant roots at extreme left.

PLATE V

Figure 1. Shows heavy sandy clay which underlies many of the areas of white sands. Light colored vertical and horizontal streaks are white kaolin. Dark colored layer above is organic hardpan.

Figure 2. Highly podzolized soil profile about 4 miles south of Humacao. Soil is derived from quartz diorite and occurs near a hill top. Drainage good. Note strong development of whitish A_2 horizon just above heavy B horizon at center of photograph. Profile similar to the one described from Mayagüez and represents same soil-forming process which caused the formation of the white sands.

PLATE IV.

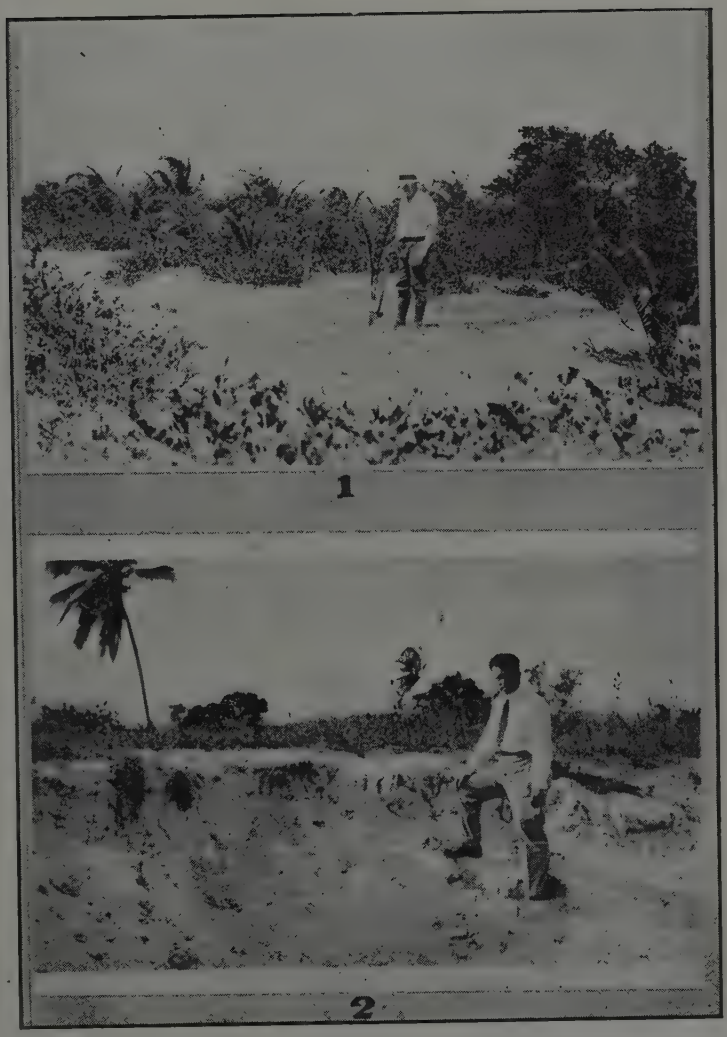
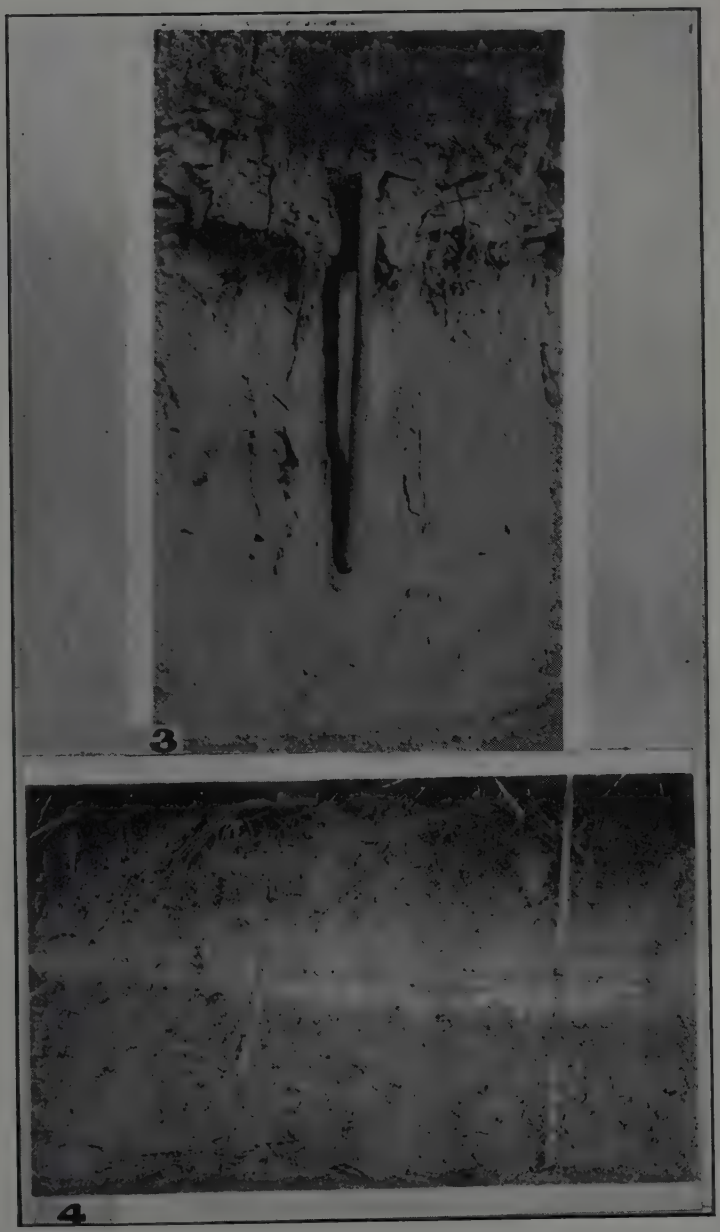


PLATE V.



PUERTO RICO SEEDLESS ORANGE SELECTIONS

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During the months of August and September, 1928, the senior writer visited the principal fruit-growing districts of Puerto Rico in order to study the varieties of citrus fruits grown and to introduce improved methods for the propagation of selected strains of the commercial citrus fruits. This visit was made in response to an invitation by the Commissioner of Agriculture and Labor of Puerto Rico and with the cooperation of the Bureau of Plant Industry of the U. S. Department of Agriculture. The selection and propagation study of citrus problems was cut short by a severe hurricane that occurred on September 13 and 14 but important information had been obtained before the terrific storm known locally as the San Felipe hurricane, interrupted the investigation. During the search for a superior orange amongst the so-called "wild" or seedling trees an outstanding tree bearing seedless oranges of apparent commercial value was discovered and propagated. This report will contain an account of the discovery and the description of the characteristics of this tree and its fruit and of three others that were found and propagated subsequently.

Discovery of Seedless Orange

Upon his arrival at San Juan, Puerto Rico, in August, 1928, the senior writer met with Hon. C. E. Chardon, then Commissioner of Agriculture and Labor, at his office in the Insular Experiment Station at Río Piedras, in order to decide upon a plan for investigating citrus-bud-selection problems. At this meeting the senior writer proposed amongst other things a systematic search for superior orange trees, particularly amongst the plantings of the so-called "wild" orange trees that are located on various coffee plantations of the hill districts and in the gardens of Puerto Ricans, many of whom have shown a special interest in the planting and study of orange varieties.

During a previous visit to Puerto Rico in 1905, the senior writer has been impressed by the marked variation in the commercial quality of the Puerto Rican oranges that came under his observation at that time. This experience together with a similar one in California citrus orchards during the past twenty-three years were the reasons that led to the proposal of study of the seedling orange trees in Puerto Rico during the Fall of 1928 from the standpoint of determining, so far as possible, the nature of variations, if any, in the trees and their fruits and particularly to look for individual trees that were apparently superior to the average for commercial propagation and culture in Puerto Rico.

A searching party was organized early in September 1928 to carry out a systematic search for a superior orange in certain citrus-growing districts of Puerto Rico. The members of the expedition consisted of Mr. O. W. Barrett, then in charge of farm demonstration work for the Puerto Rico Department of Agriculture and Labor and whose knowledge of local agricultural conditions and familiarity with the Spanish language were valuable in this work, Mr. A. Mayoral of the Plant Propagation Station at Trujillo Alto, and the senior writer. The equipment included a supply of sphagnum moss and suitable containers for budsticks in order to insure the proper care for any budwood that might be obtained from any outstanding tree that might be discovered.

Several days were spent in studying orange trees in various locations on the Island but without finding any particularly valuable orange trees of interest from the commercial standpoint. A few selections of budwood from interesting trees that were thought to be better than the average were made but these trees were considered to be of minor commercial importance by the senior writer. While the fruits of these selected trees were apparently superior in one or more commercial characteristics to the average, the fruit and foliage characters did not meet all of the requirements that were considered to be essential for a superior orange variety.

Finally, on September 11th, 1928, a visit was made to a coffee plantation owned by Don Francis Martínez, located in the hill country above the city of Mayagüez and about 1,200 feet above sea level. The orange trees on this plantation, probably more than a thousand in number, were planted for the most part alongside the coffee fields and as a shade for the coffee plants. They were about forty years old, according to the superintendent of the plantation who accompanied us during our study of these trees. They were typical so-called "wild" or mountain orange trees, i. e. apparently seedlings of

the varieties introduced by the Spanish explorers and settlers during the early history of the colonization of Puerto Rico. The principal crop on this plantation was coffee and the maintenance of the orange trees was incidental to the main business of the plantation. In addition to those planted alongside and in the coffee fields, small groups of orange trees were found growing near the houses of the employees as was frequently the case on similar plantations in other districts that were visited during the course of the survey.

At the time of this reconnaissance, the fore part of September 1928, the fruits of most of the orange trees observed were young and small, about the size of walnuts on the average. Now and then a tree was found with larger and more mature oranges while others had only very small fruits. All of the fruits examined from the most promising-looking trees contained several seeds and some of them had as many as 35 or more seeds each. In some instances the rinds were very thin and in others the peels were quite thick. Most of the oranges examined had a tender rag and were very juicy but some of them contained an excessive amount of coarse rag and were lacking in juice. In some instances the flavor of the juice was fair to good but in most cases it was insipid and poor.

Amongst the orange trees in the main border row of the Martínez plantation several apparently interesting ones were examined but upon close study they were found lacking in one or more of the characteristics essential for a superior commercial orange by reason of the undesirable shape, size, rough texture, poor flavor, lateness of maturity, excessive number of seeds or other characters of commercial importance. As a result no attempt was made to collect budwood from any of the trees that were first examined. After walking about half the length of the row, the senior writer noticed in the distance a conspicuous tree that stood out from the neighboring ones so that it attracted his immediate interest. The characteristics of this tree that were particularly noticeable to the senior writer while still some distance from it, included: an unusually large crop of apparently mature oranges having uniformly desirable commercial size and shape, the relatively large size of the tree and its dense, deep green foliage with large, clean, healthy appearing leaves. Instinctively, the senior writer felt at the time that this might be the tree for which he had been searching, but restrained his enthusiasm until it was possible to examine the foliage and the fruits more closely.

Upon reaching the conspicuous tree the senior writer picked an orange nearest at hand and cut it traversely across the mid section. The first glance at the cross section showed that the orange has a

medium thickness of peel, the flesh was firm and had an attractive texture and color, the core was very small and solid and no seeds were visible. Small sections were immediately cut from the two halves and handed to members of the party. After tasting these samples everyone present agreed that the flavor of the juice, texture of the flesh, and the bouquet or aroma of this fruit was superior to any of the samples tasted heretofore on this trip or to the best of their recollection in any previous tests. The fruit was found to be entirely without seed or any evidence of seediness. The senior writer then cut, in a similar manner, 24 other oranges that were picked from different branches of this tree and every one without exception proved to have very similar characteristics to those of the first one examined, including absence of seeds, firm and very tender flesh, no apparent core, an abundance of excellent flavored juice, medium thicknesss of rind and exceptionally desirable size and shape of orange from the commercial standpoint. The unanimous opinion of those present was that this was the best eating orange that they had tasted to the best of their recollection.

About 50 budsticks were then cut from this outstanding tree, each with one or more typical fruits attached. The fruits were cut off from the budsticks and their characteristics noted, particularly the absence of seeds. The budwood was carefully labelled and immediately packed in moist sphagnum moss. A few additional oranges were also picked from the tree for subsequent examination.

The remaining orange trees in the row were looked over before the party left the plantation but nothing of particular interest was observed. By this time darkness precluded any further field studies and the party returned to Mayagüez for the night. On the morning of September 12, 1928, a visit was made to several Mayagüez gardens and the party started on their return trip to San Juan. En route a stop was made at San Sebastián where several small garden orange plantings were looked over. One of the growers reported an orange tree located on his coffee plantation some distance from the city that produced characteristically seedless and desirable fruits. Arrangements were made to visit this planting subsequently in order to obtain further data and budwood for possible propagation but owing to circumstances the senior writer was unable to carry out this plan.

While at San Sebastián during the afternoon of September 12th one of the growers mentioned the fact that a hurricane had been reported from the Virgin Islands and that it was apparently approaching Puerto Rico. Accordingly haste was made to return to San Juan, but a short stop was made at Garrochales in order to visit one

of the larger Grape Fruit orchards. While at Garrochales showers began to fall and the southwestern sky developed a leaden or coppery appearance that indicated, according to the experienced members of the party, the approach of a hurricane. San Juan was reached late in the evening of September 12th and about midnight the hurricane arrived, the first stages of which consisted of terrific gusts of wind that were accompanied by a torrential downpour. On the following day the hurricane persisted until about five o'clock when a calm period occurred. Later, about nine o'clock in the evening, the wind began to blow again with hurricane violence, tho not so strongly as during the first phase of the storm, and continued until about eight o'clock of the morning of September 14th. On the following day, September 15th, the buds from the outstanding Martínez Orange tree were inserted in seedling rootstocks in propagating grounds and nursery located at Trujillo Alto, near San Juan. The leaves of the young rootstocks had been badly whipped by the violent windstorm but the seedlings were still in fairly satisfactory condition for budding on account of the fact that they were located in a sheltered place. The young nursery trees resulting from this propagation were eventually distributed in the model farms and to growers for tests of the new variety for commercial orange production.

On account of the widespread damage to Agriculture as a result of the terrific hurricane further study of the native orange trees were abandoned for the time being and the senior writer returned to Washington, D. C. However, before leaving, the senior writer drew up a systematic plan for a study of these trees and when conditions became settled after the disaster further search was made for outstanding trees. Three additional selections have been made during recent years and descriptions of these outstanding trees and samples of fruits from them are included in this report.

In January, 1931, Edmund H. Twight, of Riverside, California, the junior author, was appointed Specialist in Fruits for the Insular Experiment Station by the Puerto Rico Department of Agriculture and Commerce. He has been instrumental in bringing together the other three Rico oranges and in collecting much of the data contained in this paper. On January 8, 1932, the senior author received at Riverside, samples of the four Rico oranges from the junior author. They were picked from the selected parent trees as noted in the description. Those fruits under California quarantine regulations were shipped to Riverside from Puerto Rico in care of the Riverside County Agricultural Commissioner, in whose office they

were examined and photographed after which they were carefully burned in order to eliminate any possibility of the introduction of insect pests or disease. In addition to the personal studies of these oranges, the senior writer obtained the services of three of the leading orange growers and packers in the Riverside district in order to secure their opinions as to the commercial value of each sample and particularly their judgment as to the most desirable one of the four varieties for a commercial orchard test. Fortunately the Agricultural Commissioners of the Southern California Counties were meeting where these fruits were examined and their opinions as to the fruit characteristics and their apparent commercial value were also obtained.

The circumference and weight of each orange in all of the samples were recorded, systematic notes were made as to the color, thickness and texture of the rinds, shape of the fruit, color of flesh, character of the rag, the amount and color and flavor of the juice, the size and nature of the core, the number of segments in a typical fruit of each sample, the number of seeds, if any, the presence or absence of a navel and the soluble solids-acid ratio of the juice of a composite sample made up from three oranges of each lot were recorded. Photographs of each sample of fruits were made but owing to the poor lighting conditions in the room where the photographing was done the resulting pictures are not as clear as would have been under more favorable conditions. Each sample was examined by all those present during these tests by tasting and thru systematic inspections of the inner and outer characteristics of the fruits. Ample time was available so that opportunity was given to study the oranges adequately and to consider their characteristics from different points of view.

Some of the outstanding characteristics of the samples of oranges were: the absence of seeds, their desirable shape, size and texture from the commercial point of view, the fine bouquet and flavor of the juice, the small amount and melting character of the rag, and the good outside color of the oranges even though they had not been washed or treated in any way in order to improve their appearance. Some smut from scale was found on most of the fruits but that could have been easily washed off. Treatment with Ethylene gas would doubtless have improved their color from the commercial standpoint, but at that time it was considered best to photograph and record the descriptive notes without any cleaning or other fruit treatment.

The writers know of only one commercial orange variety, the trees of which characteristically bear seedless fruits in the South-

west, the Washington Navel Orange, which is one of the most important orange varieties grown. For this reason, if for no other, the orange selections described in this report are of scientific interest and one or more of them are likely to be commercially important. The particularly attractive flavor and bouquet of the abundant juice, the melting and very tender nature of the small amount of rag and the desirable commercial sizes and shapes of the fruits makes them of more than ordinary interest.

Following are the descriptive notes obtained from the examination of the fruits of the Puerto Rico orange selections that were sent to the senior writer from Puerto Rico by the junior author of this report. In addition to the data obtained from a study of the samples of fruit, notes are presented that give the facts concerning the location, discovery and propagation of each parent tree together with the description of some of the most important parent tree characteristics from data obtained largely by the junior author in the course of his official duties in Puerto Rico during the season of 1931.

The parent-tree selections have been given temporary names and numbers in order to identify them, the first one found being called Rico No. 1, the second Rico No. 2. and the other two Rico No. 5 and Rico No. 6. No fruits have been produced by the progeny trees as yet but their foliage indicates that the characteristics of the parent trees have been probably perpetuated through bud propagation.

Location and Characteristics of the Rico No. 1

This tree is located on the mountain coffee plantation owned by Don Francisco Martínez in the Mayagüez district of Puerto Rico at an elevation of about 1,200 feet above sea level. The soil on this plantation is red clay. The tree was discovered by A. D. Shamel on September 11, 1928, and the first progeny propagation was made on September 15, 1928, at Trujillo Alto in the nursery of the Plant Propagation Station. The nursery progeny was subsequently planted at the Propagation Station, the Insular Experiment Station, the various Model Farms and the Orchard of Hill Bros. at Sabana Llana. The young progeny tree had some fruit this year (1932) but the San Ciprián hurricane of September 26 (1932) shook them off; the trees, however, were not damaged. The parent tree is about forty years old, about 30 feet high, has a spread of about 30 feet, the diameter of the tree three feet from ground is about 12 inches. As the result of the hurricane of September 1928, the heavily laden tree was seriously injured and is now in very poor condition altho at the time of its discovery it was very vigorous. The habit of growth

of this parent tree is erect, the yield for 1932 was estimated at from 3 to 4 cases of oranges, the uniformity of the fruit is good and the commercial quality of the oranges is excellent. The tree is located on a shady mountain slope, one in a row of oranges that form a border for the adjacent coffee plantation.

DESCRIPTION OF SAMPLES OF RICO ORANGE No. 1

Individual Orange Number	Weight Ounces	Circumference Inches
1	11½	10 10/16
2	11½	10 7/16
3	11	10 7/16
4	10	9 13/16
5	9	9 11/16
6	8½	9 9/16
7	8	9 4/16
8	8	9 8/16
9	8	9 8/16
Average	9.5	9.81

The color of the rinds of the fruits is deep yellow with a reddish tinge, the texture is smooth; the shape of the fruit is slightly obovoid; the peel is about 3/16 of an inch thick, the flesh is firm, has a deep yellow color, exceptionally small amount of tender rag and excellent eating quality; the juice is abundant, 3 oranges producing about one pint; the color of the juice is yellow and more attractive than that of the other samples of Rico oranges examined, the flavor is excellent, eleven segments in one orange; small solid core; no seeds; no navel; soluble solid-acid ratio 11.8 to 1.

Location and Characteristics of the Rico No. 2

The parent tree Rico No. 2 was located by Julio S. Simons, Superintendent of the San Sebastián Demonstration Farm during 1930 on the mountain coffee plantation owned by Don Francisco Roig in Barrio Perchos between San Sebastián and Lares, about one and half hour on horse back from the highway. The tree is located about 2,000 feet above sea level. The soil is a heavy reddish clay. The first progeny propagation of this tree was made by A. Mayoral at the San Sebastián demonstration farm and at the Plant Propagation Station of Trujillo Alto on February 15, 1930, and another was made in June, 1931, by E. H. Twight. The resulting nursery progeny trees were planted subsequently at the Plant Propagation Station of Trujillo Alto and at the San Sebastián Model Farm.

This parent tree is about 40 years old, has a height of about 30 feet and a spread of about 30 feet. The diameter of the trunk three feet above the ground is about 12 inches. The vigor of vegetative

growth is good and the crop for 1932 is estimated to be from 3 to 4 cases. The fruit is fairly uniform with the exception of that on the central growth. The tree has an erect habit of growth. It is growing on a steep hillside and in partial shade.

DESCRIPTION OF SAMPLES OF RICO ORANGE No. 2*

Individual Orange Number	Weight Ounces	Circumference Inches
1	12	10 $^{8}/_{16}$
2	11	10 $^{4}/_{16}$
3	11	10 $^{4}/_{16}$
4	10	10 $^{3}/_{16}$
5	10	9 $^{15}/_{16}$
Average	10.8	10.23

* 3 oranges badly effected with brown rot decay, not included.

The color of the rinds is deep yellow tinged with red, the texture is smooth; the shape of fruit is obovoid; the peel is 3/16 of an inch in thickness; the flesh is firm, has a deep yellow color, tender rag and good eating qualities; the juice abundant, 3 oranges producing a little less than a pint of juice and has a fine distinctive flavor; the core is small and solid; 9 segments in one fruit; small rudimentary navels in rinds at blossom ends of the fruit with very small navel opening or practically closed; no seeds; soluble solid-acid ratio: 14.5 to 1.

Location and Characteristics of the Rico No. 5

This tree is located on the mountain coffee plantation owned by Don Ignacio Roig near Guayanilla in the southwestern part of the Island and about two hours by horseback from the highway (Kilometer 241) at an elevation of about 2,000 feet above sea level. The soil is a heavy clay loam. This parent tree was located by Félix A. Velasco, Agricultural Agent at Guayanilla, in the Fall of 1930. As in the case of the Rico No. 2 and of the Rico No. 6 parent trees, the owner had known for years that this particular tree was prolific and produced each year crops of commercially desirable and seedless oranges. Progeny propagation of this parent tree was first made during the Spring and Fall of 1931 at the Insular Station at Río Piedras and at the Plant Propagation Station at Trujillo Alto by the junior author, and again in 1932.

The parent tree is about 40 years old, about 30 feet high and has a spread of about twenty-five feet. The diameter of the trunk three feet above ground is ten inches. The vigor of vegetative growth is good and the yield of fruit is about 3 cases annually. The fruit is

uniformly good. The tree has an upright habit of growth but leans to the northwest on account of prevailing winds. It is located on a steep mountain slope and stands on a ledge that overhangs a dashing mountain stream.

DESCRIPTION OF SAMPLES OF RICO ORANGE No. 5

Individual Orange Number	Weight Ounces	Circumference Inches
1	15	11 14/16
2	14	11 10/16
3	13	11 6/16
4	13	11 1/16
5	12½	10 12/16
6	12	10 15/16
7	12	10 12/16
8	9	9 15/16
Average	12.5	11.06

The color of the rind is light yellow, the texture somewhat coarse; the shape of the fruit is slightly obovoid but more spherical than in the case with the other samples; the peel is about 4/16 inch thick; the flesh has a deep yellow color and the rag tender; the juice abundant and has a good color; 3 oranges produced one pint of juice; the core is open and about 10/16 inch in diameter; ten segments in one fruit; one large imperfect seed was found in 5 fruits; no navels; the soluble solid-acid ratio: 12.5 to 1.

Location and Characteristics of the Rico No. 6

The parent tree of the Rico No. 6 is located on the mountain coffee plantation owned by Don Carmelo Albino Bisot near Sabana Grande and about two hours by horse back from Sabana Grande. The soil is a heavy reddish clay with a shallow covering of black loam. The tree stands at an elevation of about 2,000 feet above sea level.

It was located by Félix A. Velasco, Agricultural Agent, Guayanilla, and was propagated at the Insular Experiment Station at Río Piedras in March, 1931. The resulting progeny trees were planted at the Plant Propagation Station at Trujillo Alto in April, 1932, by the junior author. The parent tree is about forty years old, thirty feet high and has a spread of about thirty feet. The trunk diameter three feet above ground is about 12 inches. The vigor of vegetative growth is good, the production fair and the fruits are fairly uniform. The habit of tree growth is erect and the tree is growing on a shady mountain slope. As with the other selected parent trees, Rico No. 1, Rico No. 2 and Rico No. 5, no pruning, cultivation, spraying, soil fertilization or other care has been given this tree.

DESCRIPTION OF SAMPLES OF RICO ORANGE No. 6

Individual Orange Number	Weight Ounces	Circumference Inches
1	11⅛	10 13/16
2	10	10 6/16
3	9½	9 12/16
4	9	9 11/16
5	9	9 7/16
6	9	9 7/16
7 Very flat	7½	9 6/16

The color of the rind of fruit is deep yellow tinged with red and the texture is smooth, the shape of the fruits is somewhat flattened as with the Marsh Grape fruit; the peel is about 4/16 of an inch thick; the flesh is deep yellow in color and has a tender rag; the juice is abundant and of exceptionally fine flavor, three and one-half oranges produced a pint of juice; 4 fruits had a total of four perfect and two imperfect seeds and two fruits were seedless; no navel; soluble solid-acid ratio: 12 to 1.

Explanation of Plates

Plate VI. Typical fruits from seedless orange selection Rico No. 1. Original tree near Mayagüez, Puerto Rico.

Plate VII. Typical fruits from seedless navel orange selection Rico No. 2. Ranch of Mr. Roig, San Sebastián, Puerto Rico.

Plate VIII. Typical fruits from seedless orange selection Rico No. 5.

Plate IX. Typical fruits of seedless orange selection Rico No. 6. Sabana Grande.

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PLATE VI.

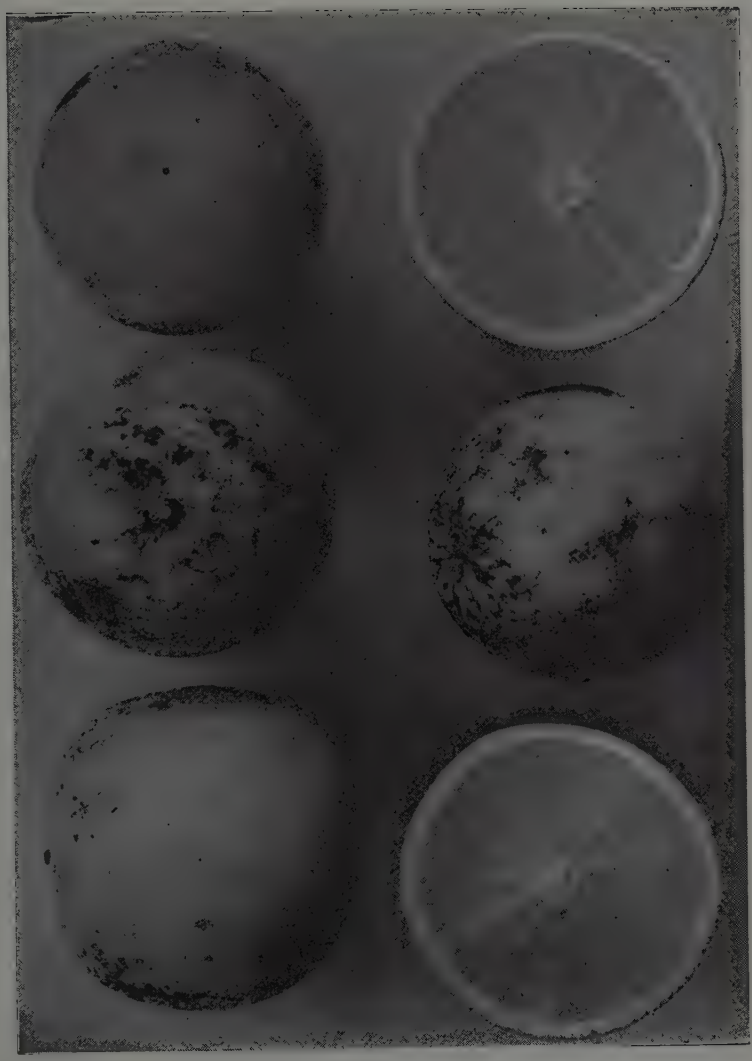

PLATE VII.

PLATE VIII.

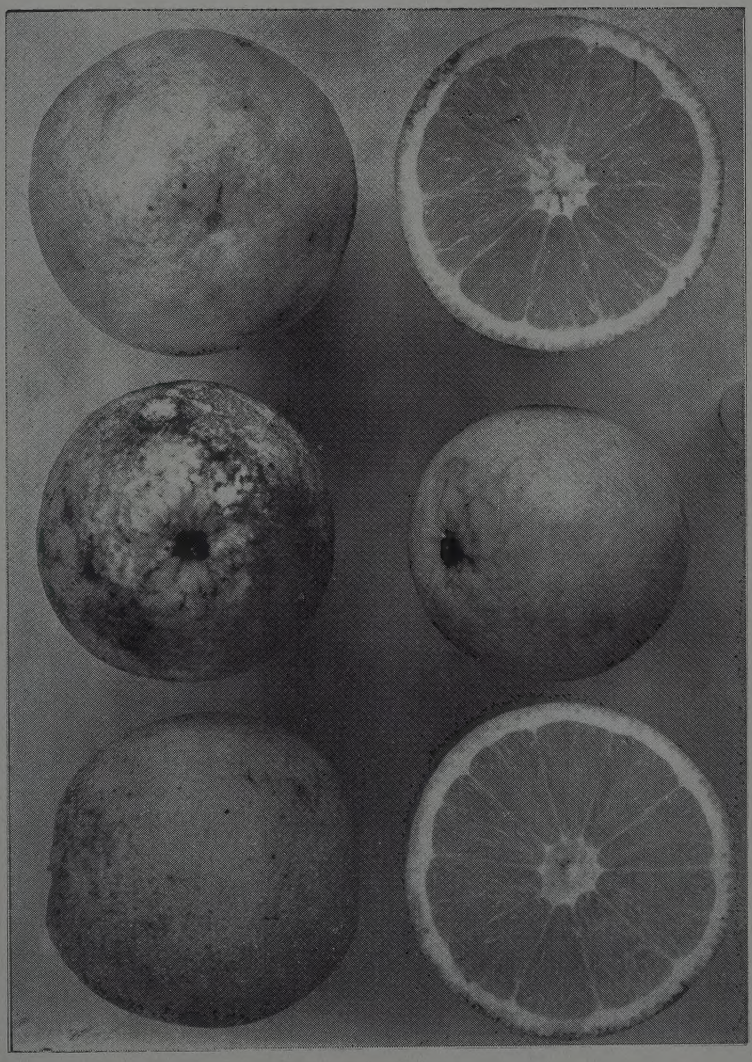

PLATE IX.